



BULLETIN
OF THE
MADRAS GOVERNMENT MUSEUM

EDITED BY
THE DIRECTOR OF MUSEUMS

THE ECHINODERMATA

In the collection of the Madras Government Museum

BY
S. THOMAS SATYAMURTI, M.A., D.SC., F.Z.S.
Director of Museums, Madras Government Museum

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BY
S. THOMAS SATYAMURTI, M.A., D.SC., F.Z.S.
Director of Museums, Madras Government Museum

Published—1976

ACKNOWLEDGEMENTS

In the preparation of this Monograph I have received considerable help from several persons, especially the members of the staff of the Zoology Section of this Museum and some of the other members of the technical staff of this Museum. I therefore wish to place on record my deep appreciation and to express my sincere gratitude to them for their valuable assistance. In particular, I wish to thank Miss A. Vimala, the former Assistant Curator of the Zoology Section of this Museum for her kind help in furnishing me with English translations of much relevant original literature in German on Echinoderms, Mr. P. Jawahar, the present Assistant Curator of the Zoology Section for his generous help in preparing the index to this Bulletin, Mr. G. Kesavaram, Curator of the Zoology Section and Mr. G. Srinivasan, Photographer of this Museum for their kind assistance in preparing the photographs used for the illustrations in this volume and Mr. R.N. Meganathan, Artist modeller of this Museum for preparing the line drawings included in this Bulletin. Finally, I would like to express my deep debt of gratitude to Mr. D.B. James, M.Sc., Research Officer, Central Marine Fisheries Research Unit, Port Blair, Andamans, for the keen interest he had all along evinced in the progress of my work on Echinoderms and for his continued encouragement and valued assistance in providing me with reference to recent literature on Echinoderms.

MADRAS,

Dated 22nd June 1976.

S. THOMAS SATYAMURTI,

*Director of Museums,
Government Museum, Madras-8.*

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Vol. III, No. 6, 1940.	Decapod Larvae from the Madras Plankton—II. By M. Krishna Menon, M.A., M.Sc.	47	8	1 50	1 11
Vol. IV, No. I, 1931.	The Indian Species of Genus Caralluma (Fam. Asclepiadaceae). By F. H. Gravely, D.Sc., and P. V. Mayuranathan, B.A., Government Museum, Madras.	28	4	1 50	1 1

† This number is reserved for supplements to Krusadai Island, Fauna.

‡ Out of stock.

Astropecten mauritianus Gray.

FIGURE 58.

Astropecten Mauritianus, Gray, Annals and Magazine of Natural History, 1840, Vol. VI. p. 182.

Astropecten Mauritianus, Gray, Synopsis of the Species of Starfish in the British Museum (Natural History), London, 1866, pp. 3 and 4.

Astropecten mauritianus, Perrier, Revision de la Collection des Stellerides du Museum d' Histoire Naturelle de Paris, Arch. Zool. Exp. (1), Vol. IV and V, 1875-76, p. 359.

Astropecten mauritianus, Rudmose Brown, Echinoidea and Asteroidea from the Mergui Archipelago and Markos Islands, Lower Burma, Proc. Roy. Phys. Soc. Edinburgh, XVIII, No. 1, P. 29.

Astropecten mauritianus, Koehler, "Shallow Water Asteroidea, Indian Museum, Calcutta, 1910, pp. 32 - 37, pl. v, figs. 7 to 9.

Astropecten mauritianus, Gravely, "Shells and Other Animal Remains of the Madras Beach", Bulletin, Madras Govt. Museum, (Natural History), V. No. 1, 1941, p. 86, fig. 30, 1; p. 105.

Koehler (*loc. cit.*) reports a large range of sizes among the specimens of this species examined by him in the Indian Museum Collection. He cites the following range of measurements for this species:—

In the largest specimen from Seven Pagodas, Mahabalipuram, $R = 87$ mm., $r = 16$ mm.; in a second specimen from the same locality, $R = 69$ mm., $r = 15$ mm.

In other specimens, the value of R is reported to vary between 67 and 51 mm.; finally, in the three smaller specimens collected from Gopalpore, R ranges between 39 and 31 mm., and r between 10 and 9 mm. In the specimen which had been sent to Koehler from the Mergui Archipelago by M. Rudmose Brown (which is apparently the largest recorded for this species), $R = 111$ mm., and $r = 21.5$ mm.

The disk is of average (or medium) size. The arms are rather slender at the base and they gradually and regularly taper up to the extremity which is pointed. The dorsal surface of the disk and of the arm is very slightly swollen or arched, and the ventral surface is flattened. The body is rather thin and does not appear to be very robust.

The dorsal surface of the disk bears the paxillae which are very small and confluent in the central region, but which become rapidly larger. They measure 1.7 mm. in diameter at the periphery of the disk and at the base of the arm in the large specimen examined by Koehler and 1.5 mm. in the next smaller specimen. They bear central granules, rounded and rather large, sometimes disposed irregularly and sometimes forming a circle around a single central granule, and of which the number ranges up to a dozen in the larger paxillae of the large individuals. The peripheral circle comprises more elongated granules. The size of the paxillae diminishes rapidly outside the limits of the disk, and at the commencement of the arms the central granules become very much less numerous, while the peripheral granules do not vary. Thus the paxillae occurring further beyond, on the arms, bear only one or two central granules with a peripheral border of eight or ten elongated granules. On the arms, the paxillae form a median raised ridge, in which they are rather large, and, on the sides, form transverse rows in which

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†Vol. V, No. 1, 1941.	Shells and other Animal Remains found on the Madras Beach, I, Groups other than snails, etc. By F. H. Gravely, D.Sc.	112	Nil.	3 12	2 34
†Vol. V, No. 2, 1942.	Shells and other Animal Remains found on the Madras Beach. II. Snails, etc. (Mollusca Gastropoda). By F. H. Gravely, D.Sc.	110	Nil.	2 75	2 07
Vol. VI, No. 1, 1949.	The Thaliacea of the Madras Plankton, By R. Velappa Nair, M.Sc.	41	1 32
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Vol. VI, No. 3, 1959	The Amphipoda of the Madras Coast. By K. Nagappan Nair, M.Sc.	59	16	4 35	3 27
Vol. VI, No. 4, 1960	The Land and Freshwater Mollusca in the Collection of the Madras Government Museum, By S. T. Satyamurti, M.A., D.Sc., F.Z.S.	174	21	13 00	9 75
1960.	Guide to the Snakes exhibited in the Reptile Gallery. By S. T. Satyamurti, M.A., D.Sc., F.Z.S.	25	..	0 75	0 57
1961	Guide to Snakes exhibited in the Reptile Gallery (Tamil). By S. T. Satyamurti, M.A., D.Sc., F.Z.S.	26	18	0 62	0 47
1962	Guide to the Lizards, Crocodiles, Turtles and Tortoises exhibited in the Reptile Gallery. By S. T. Satyamurti, M.A., D.Sc., F.Z.S.	45	28	1 37	1 03
1963	Guide to the Galleries of Foreign Animals, General Zoology, Skeletal exhibits and Amphibians. By S. T. Satyamurti, M.A., D.Sc., F.Z.S.	65	40	3 00	2 25
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1967	Guide to Invertebrate Galleries by S. T. Satyamurti, M.A., D.Sc., F.Z.S.	164	66	7 05	5 29
Vol. VII, No. 1, 1966	Descriptive catalogue of the Butterflies in the Collection of Madras Government Museum by S. T. Satyamurti, M.A., D.Sc., F.Z.S.	355	32 (colour)	30 95	23 18
Vol. VIII, No. 2, 1967	The South Indian Amphibia in the collection of Madras Government Museum, by S. T. Satyamurti, M.A., D.Sc., F.Z.S.	90	13	5 80	4 35
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*Vol. VIII, 1963 ..	Bronzes of South India. By P. R. Srinivasan, M.A.	396	205	57 00	42	75
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	Guide to the Bronze Gallery by V. N. Srinivasa Desikan, Curator for Archaeology.	52	22	3 50	2	62

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THE ECHINODERMATA

IN

THE COLLECTION OF THE MADRAS GOVERNMENT MUSEUM

BY

S. T. SATYAMURTI, M.A., D.SC., F.Z.S.

(Director of Museums, Government Museum, Madras)

INTRODUCTION

The earliest published report of the Echinodermata represented in the collection of the Madras Government Museum appeared in the Bulletin of the Madras Government Museum (New Series), Natural History Section, Vol. I, No. 1, 1927, entitled "The Littoral Fauna of Krusadai Island, in the Gulf of Manaar" (at pages 163 to 173) by Dr. F. H. Gravely, D.Sc., who was then the Superintendent of the Madras Government Museum. That paper deals with the Littoral Echinoderms collected from Krusadai Island and its neighbourhood in the Gulf of Manaar, and represented in the collection of the Madras Government Museum. Besides furnishing a brief systematic report on the species of Echinoderms then known to have been collected from Krusadai Island and its vicinity, it contains a valuable bibliography, listing most of the important monographs on Echinodermata available up to that time, and has been a most helpful reference work for identifying many of the species of the common littoral Echinoderms collected from Krusadai Island and its environs in the Gulf of Manaar for the past several years. However, only in the case of Holothurians have fairly detailed specific descriptions been furnished in that Bulletin, while the recorded species of the other groups (Asteroidea, Ophiuroidea, Echinoidea and Crinoidea) are only rather scantily described, the descriptions in most cases being reduced to at most one or two lines or even a mere passing mention. Further, there are no illustrations at all of even a single species of Echinoderms recorded in that Bulletin. The Bulletin itself has since become out of print and efforts to reprint it have not so far materialized in view of the existing financial stringency. The only other subsequent Bulletin of this Museum that deals, at least in a cursory manner, with some of the more common South Indian Coastal Echinoderms — particularly those found washed up as dry specimens on the Madras Beach — is the much later publication, namely, the Bulletin of the Madras Government Museum entitled "Shells and other Animal Remains of the Madras Beach", Vol. V, No. 1, 1941, by Dr. F. H. Gravely, but even this extremely useful and practical handbook on the Madras Beach Fauna has since become out of stock and out of print, and consequently there is at present no Bulletin of this Museum available, containing a comprehensive systematic report on all the South Indian Littoral Echinoderms (including also a few deep sea forms) which are contained in the collections of this Museum (both in the exhibited series in the Gallery and in the reference collections).

The necessity for compiling and bringing out a revised descriptive and comprehensive account of the South Indian Coastal Echinoderms represented in the collections of this Museum was therefore keenly felt, and when, with this object in view, I re-examined the collections of Echinoderms contained in this Museum, I found, to my surprise, that a number of species actually represented in the collections of this Museum

were not mentioned at all in either of the two Bulletins previously published by this Museum, dealing with Echinoderms and referred to above, as detailed below:—

<i>Class.</i>	<i>Number of species represented in the Museum collection.</i>	<i>Number of species not mentioned in either of the two preceding Bulletins of this Museum.</i>
1. Asteroidea	24	17
2. Ophiuroidea	13	7
3. Echinoidea	25	13
4. Holothurioidea	18	5
5. Crinoidea	3	..
Total..	83	42

It is evident, therefore, from the foregoing table, that almost exactly half the number of species represented in the Museum collection have not been reported or even mentioned in either of the earlier Bulletins of this Museum dealing with Echinoderms.

Thus it would be readily appreciated that although a number of species of common littoral Echinoderms occur on the South Indian coasts and although specimens of a number of these species have been collected, identified and added to the reference and gallery collections in this Museum, there is at present no convenient illustrated handbook in English giving adequate descriptions of these commonly occurring South Indian coastal species, together with synopses of the characters of the various orders, families and genera to which these species belong, which would enable students and amateur collectors to readily identify and classify the specimens of Echinoderms they might collect. Besides, there is at present no volume on the Echinodermata in the Fauna of India Series, and this is also a serious handicap which has greatly increased the difficulties of students, teachers and research workers who are in need of a basic systematic account in English, with illustrations, of at least the more common littoral Echinoderms found on the Indian Coasts.

It was therefore felt that it might prove helpful and fulfil a long-felt need if a revised, up to date and comprehensive paper could be published presenting a fairly complete systematic account of all the species of Echinoderms so far collected by this Museum and at present contained in the collections of this Museum, not only from Krusadai Island in the Gulf of Manaar, but from other localities as well, with adequate references and illustrations. The present descriptive Catalogue has therefore been compiled primarily to fulfil this need, and in presenting this account attempts have been made not only to arrange the species according to the currently accepted order of classification, but also to include the descriptions of the orders, families and genera in addition to the specific descriptions as adequate English descriptions of genera and families and of even the larger classificatory categories such as the orders are not generally found included in most of the monographic systematic works available on this Phylum, although they are helpful for a clearer understanding of the classification and relationships between the members of this large, heterogeneous and complex group of marine Invertebrates.

In the present account, the description of each species is followed by brief notes on the specimens of that particular species represented in the Museum collection, together with data pertaining to their locality, state of preservation, colour, measurements, etc., and efforts have been made to furnish, as far as possible, clear illustrations of specimens of almost every species included in the Paper.

Since the Museum's collection of Echinoderms of the South Indian Coastal Regions is fairly representative and contains many of the common species recorded from this area, it is hoped that the present account will serve as a descriptive guide to the common species of this group occurring in this area and will prove helpful in identifying at least most of the commoner species of Echinoderms occurring on these coasts.

The classification followed in this Paper is that adopted by Dr. Libbie H. Hyman in her treatise on the Invertebrata, Vol. IV Echinodermata, as this appears to be the latest and most currently accepted classification of this Group at present available. As the species represented in the Museum Collection belong only to living groups a broad outline of this Classification, omitting the extinct groups is furnished below:—

PHYLUM ECHINODERMATA

SUB PHYLUM PELMATOZOA

Class CRINOIDEA (Sea Lilies).

SUB PHYLUM ELEUTHEROZOA

Class HOLOTHURIOIDEA (Sea Cucumbers).

Class ECHINOIDEA (Sea Urchins, etc.).

Subclass Regularia or Endocylica.

Subclass Irregularia or Exocyclica.

Class ASTEROIDEA (Sea Stars).

Class OPHIUROIDEA (Brittle Stars).

SYSTEMATIC LIST OF THE SPECIES OF ECHINODERMS REPRESENTED IN THE COLLECTION OF THE MADRAS GOVERNMENT MUSEUM

Phylum ECHINODERMATA

Sub Phylum PELMATOZOA

Order ARTICULATA

Suborder COMATULIDA

Superfamily TROPIOMETRIDA

Family TROPIOMETRIDAE

Genus *Tropiometra*

Tropiometra carinata clarki

Superfamily MARIAMETRIDA

Family MARIAMETRIDAE

Genus *Lamprometra*

Lamprometra palmata

Family ANTEDONIDAE

Genus Antedon

Antedon sp.

Sub Phylum ELEUTHEROZOA

Class HOLOTHUROIDEA

Order DENDROCHIROTA

Superfamily DENDROCHIROTAE

Family CUCUMARIIDAE

Genus Cucumaria

Cucumaria conjugens

Cucumaria frauenfeldi

Genus Stolus

Stolus buccalis

Genus Thyon

Thyone mirabilis

Genus Actinocucumis

Actinocucumis typica (= *difficilis*)

Genus Pentaeta (= *Colochirus*)

Pentaeta quadrangularis

Family PSOLIDAE

Genus Psolus

Psolus complanatus

Family PHYLLOPHORIDAE

Genus Phyllophorus (= *Oreula*)

Phyllophorus (Oreula) dubia

Order ASPIDOCHIROTA (= Order ACTINOPODA)

Family HOLOTHURIIDAE

Genus Holothuria

Holothuria atra

Holothuria lubrica

Holothuria monacaria

Holothuria pardalis

Holothuria scabra (= *gallensis*)

Holothuria vagabunda

Holothuria marmorata

Family STICHOPODIDAE

Genus Stichopus

Stichopus chloronotus

Order MOLPADONIA

Family MOLPADIDAE

Genus Molpadia

Molpadia sp.

Order APODA (= Order PARACTINOPODA)

Family SYNAPTIDAE

Genus Synapta

Synapta recta (= *striata*)

Class ECHINOIDEA

Subclass REGULARIA (= ENDOCYCLIA)

Order AULODONTA

Family DIADEMATIDAE

Genus Astropyga

Astropyga radiata

Genus Echinothrix

Echinothrix calamaris

Order STRIODONTA

Family STOMOPNEUSTIDAE

Genus Stomopneustes

Stomopneustes variolaris

Order CAMARODONTA

Family TEMNOPLEURIDAE

Genus Salmacis

Salmacis bicolor

Salmacis virgulata

Genus Temnopleures

Temnopleures toreumaticus

Family TOXOPNEUSTIDAE

Genus Toxopneustes

Toxopneustes pileosus

Genus Tripneustes

Tripneustes gratilla

Genus *Gymnechinus**Gymnechinus robillardi*

Family ECHINIDAE

Genus *Echinus* (= *Parechinus*)*Echinus angulosus* (= *Parechinus angulosus*)

Family STRONGYLOCENTROTIDAE

Genus *Pseudoboletia**Pseudoboletia indiana**Pseudoboletia maculata*

Family ECHINOMETRIDAE

Genus *Echinometra**Echinometra mathaei*

Subclass IRREGULARIA (= EXOCYCLICA)

Order CASSIDULOIDA

Family ECHINOLAMPADIDAE

Genus *Echinolampas**Echinolampas obatus*

Order CLYPEASTROIDA

Family CLYPEASTRIDAE

Genus *Clypeaster**Clypeaster humilis**Clypeaster rarispinus*

Family LAGANIDAE

Genus *Laganum**Laganum decagonale**Laganum depressum*Genus *Peronella**Peronella lesueuri**Peronella orbicularis*

Family SCUTELLIDAE

Genus *Echinodiscus**Echinodiscus auritus**Echinodiscus bisperforatus**Echinodiscus bisperforatus* var. *truncatus*

Order SPATANGOIDA

Group II. AMPHISTERNOUS FORMS

Family SPATANGIDAE

Genus ~~Pseudomaretia~~

Pseudomaretia alta

Family LOVENIDAE

Genus Lovenia

Lovenia elongata

Family BRISSIDAE

Genus Metalia

Metalia sternalis

Class ASTEROIDEA

Order PHANEROZONIA

Family ASTROPECTINIDAE

Genus Astropecten

Astropecten indicus

Astropecten mauritianus

Astropecten hemprichii

Astropecten monacanthus

Astropecten zebra

Genus Persephonaster

Persephonaster rhodopeplus

Family LUIDIIDAE

Genus Luidia

Luidia maculata

Luidia savignyi

Suborder VALVATA

Family GONIASTERIDAE

Genus Anthenea

Anthenea regalis

Anthenea rudis

Anthenea pentagonula

Genus Stellaster

Stellaster belcheri

Stellaster inaequalis

Genus Goniiodiscus

Goniiodiscus granuliferus

Family OREASTERIDAE (= PENTACEROTIDAE)

Genus Pentaceraster

Pentaceraster multispinus (= *Oreaster hedemanni*)

Genus Oreaster*Oreaster thurstoni***Genus Protoraster***Protoraster linckii***Genus Asterodiscus***Asterodiscus elegans***Family LINCKIIDAE****Genus Linckia***Linckia laevigata***Family METRODIRIDAE****Genus Metrodira***Metrodira subulata***Order SPINULOSA****Family ASTERINIDAE****Genus Asterina***Asterina cepheus**Asterina coronata***Genus Anseropoda (=Palmipes)***Anseropoda sarasini***Family ECHINASTERIDAE****Genus Echinaster***Echinaster purpureus***Order FORCIPULATA****Family ZOROASTERIDAE****Genus Zoroaster***Zoroaster planus***Class OPHIUROIDEA****Order OPHIURAE****Family AMPHIURIDAE****Genus Amphiplus***Amphiplus graveleyi***Family OPHIACTIDAE****Genus Ophiactis***Ophiactis savignyi***Family OPHIOTHRICIDAE**

Genus Ophiothrix*Ophiothrix hirsuta**Ophiothrix (?) koreana**Ophiothrix aspidota**Ophiothrix galathea***Genus Ophiothela***Ophiothela danae***Genus Ophiocnemis***Ophiocnemis marmorata***Family OPHIOCOMIDAE****Genus Ophiocoma***Ophiocoma scolopendrina***Family OPHIODERMATIDAE****Genus Ophiarachnella***Ophiarachnella infernalis***Genus Pectinura***Pectinura conspicua**Pectinura intermedia***Order EURYALAE****Family GORGONOCEPHALIDAE****Genus Gorgonocephalus***Gorgonocephalus laevigatus*

**SYSTEMATIC DESCRIPTIONS OF ECHINODERMS
IN THE COLLECTION OF THE
MADRAS GOVERNMENT MUSEUM**

**SYSTEMATIC DESCRIPTIONS OF THE SPECIES OF ECHINODERMS REPRESENTED
IN THE COLLECTION OF THE MADRAS GOVERNMENT MUSEUM**

PHYLUM ECHINODERMATA

The Echinodermata is one of the most well defined and best characterized phyla of the animal kingdom. They are readily distinguished by their marked penta-radial symmetry (derived from an original bilateral symmetry), by the absence of a definite anterior end, head and brain and by the presence of a calcareous internal skeleton composed of separate plates or pieces and often bearing spines, warts or other types of protuberances externally, which account for the name of the Phylum, Echinodermata, which literally means "spiny skinned". The body usually bears five well defined radii, the ambulacra, that bear locomotor or sensory processes known as the podia (or tube feet), alternating with five interambulacra (inter-radii) around an oral-aboral axis. The body is unsegmented.

The internal organization of the Echinoderms is characterized by the presence of a well defined system of vessels of coelomic origin, known as the water vascular system. It is from this system of vessels that the podia or tube feet arise. The water vascular system communicates with the exterior by a pore or a group of pores, at least in the juvenile stages.

The sexes are usually separate, but are similar and not externally distinguishable. The larvae are bilaterally symmetrical and free-swimming before metamorphosis.

The Echinoderms are animals of moderate to considerable size. They are exclusively marine and are among the most widely distributed of all marine animals. They are found in all seas and practically at all latitudes, and in vertical distribution they range from the littoral zones up to the depths of the ocean. They are for the most part free-moving, although rather sluggish and sedentary, but they are derived from sessile ancestors, and sessile, stalked forms still survive in the Class Crinoidea (Sea lilies and feather stars). There are about 3,900 living species of Echinoderms recorded so far.

One of the most diagnostic features of this Phylum is the presence of a calcareous endoskeleton. It may consist of a series of closely articulated plates forming a rigid shell known as the *theca* or *test* (as in the Echinoidea, the sea urchins, and the Asteroidea, the sea stars), or may be composed of small, isolated pieces known as ossicles or spicules as in the Holothuroidea, the sea cucumbers, in which these ossicles take the form of microscopic pieces embedded in the integument. The spines and tubercles which project externally in most Echinoderms are also parts of the calcareous endoskeleton.

The shape of the body in the Echinoderms is subject to considerable variation. The body is either of simple contour, rounded or ovoid, (Echinoids), cylindrical (Holothurians), or star-like (sea stars and brittle stars) with simple arms which normally number five (but may sometimes be more or less than five) radiating from a central disc, or the arms may be branched and feathery, bearing lateral processes arising from a central body, which may or may not be attached to a substratum by a stalk, as in the Crinoids (Sea lilies and feather stars).

The body in the Echinoderms is differentiated into oral and aboral surfaces, the mouth being situated on the oral surface, and sea stars (Asteroidea), brittle stars (Ophiuroidea) and sea urchins (Echinoidea) lie generally with the oral surface downwards; Holothurians, however, are elongated in the oro-aboral axis and lie upon one

side which is often somewhat flattened, and the Crinoidea (Sea lilies and feather stars), whether they are attached or free-living, remain with the aboral surface directed towards the substratum and the oral surface facing upwards.

As already mentioned, the Echinodermata are divided into five Classes, namely, the Crinoidea (Sea lilies and feather stars), the Holothuroidea (Sea cucumbers), the Echinoidea (Sea urchins, etc.), the Asteroidea (Sea stars or starfishes) and the Ophiuroidea (Brittle stars and basket stars), of which the Class Crinoidea alone is grouped under the Subphylum Pelmatazoa, while the remaining four classes are included in the Subphylum Eleutherozoa. Representatives of all these Classes, mostly collected from the littoral zones on the East coast of South India, particularly the Madras Coast and the Gulf of Mannar, are contained in the collections of this Museum.

SUBPHYLUM PELMATAZOA

This Subphylum includes mostly extinct Echinoderms, attached firmly to a substratum either throughout life or in their earlier stages alone, by the aboral surface, either directly or more often by a stem-like stalk composed of a series of calcareous pieces. The body is encased in a calcareous cup or calyx-shaped skeleton. Both mouth and anus are placed in the upper or oral surface which is directed upwards. The ambulacra serve as food grooves for conducting food particles to the mouth and are usually extended distally into projecting arms which are branched. The podia, when present, are respiratory and food-procuring in function and not locomotory.

All known Echinoderms are believed to have passed through an ancestral pelmatazoic stage in the course of their evolution.

This Subphylum includes five Classes, all of which, except the Class Crinoidea (which comprise the Sea lilies and feather stars) are totally extinct. The Crinoidea includes both living and extinct forms, and comprises four Orders, of which only the last, the Articulata, includes the living forms, along with some extinct ones as well; the other three Orders of the Class Crinoidea include only extinct species.

CLASS CRINOIDEA

This Class includes living as well as extinct Echinoderms popularly known as the Sea lilies and Feather stars. The body is encased in a cup-like calcareous calyx, usually attached by a stalk, but most living members of the Class are devoid of a stalk and are not attached. The arms are branched. The ambulacra are open and the podia are simple and devoid of suckers. There is no madreporite and spines and pedicellariae are also wanting.

The calyx is composed of numerous plates arranged in penta-radiate rows and cover, on the oral surface, the tegmen which is membranous or carries supporting plates.

The arms, which are branched, may be with or without processes known as pinnules and the ambulacral grooves extend along the oral aspect of the arms and the pinnules right up to their tips. The ambulacra serve mainly as food-procuring channels. The mouth is usually centrally placed, or almost central on the tegmental surface, while the anus is usually ecentric, but sometimes central, and is placed on the same surface (i.e., oral surface), often mounted on a tube.

This is evolutionarily a very ancient group and is rich in fossil record, the species ranging from the Cambrian to the Recent, reaching the zenith of their development in the Mississippian. About 630 living and 5000 fossil species are known.

According to the earlier system of classification, all the existing Crinoids were grouped under the Order Articulata, under which the unstalked Crinoids were included in the Suborder Comatulida.

The synopsis of the characters of these groups (Order Articulata and Suborder Comatulida) are as follows.

ORDER ARTICULATA

This is the only Order of the Class Crinoidea which includes both living and extinct forms (the other three Orders, namely, Inadunata, Flexibilia and Camarata comprising exclusively extinct forms).

The Calyx in the Articulata is flexible and the tegmen is leathery, containing calcareous pieces or small calcareous plates embedded in it. The lower arm ossicles are incorporated into the Calyx. The mouth and ambulacra are exposed, although the grooves may be partially closed by the plates in the lappets.

The species represented in the Museum collection, namely, *Tropiometra encrinus*, *Lamprometra palmata* and *Antedon* sp. belong to the families Tropiometridae, Mariametridae and Antedonidae respectively, and all these three families belong to the Suborder Comatulida.

SUBORDER COMATULIDA

This Suborder includes those members of the Order Articulata which break from the main stem in the early stages of life, and thereafter lead a free existence.

The living members of this Suborder (Comatulida) are divided into two groups, namely the Oligophreata and Macrophreata forms. In the former group, which includes the majority of Comatulids, the cavity of the centrodorsal plate is small and shallow, and there are generally more than ten arms. The families Tropiometridae and Mariametridae belong to this group.

The Macrophreata forms, on the other hand, comprise ten-armed Comatulids, with a large and deep cavity in the centrodorsal, and with the tegmen naked or containing only minute calcareous particles. The family Antedonidae belongs to this group. This large and widely distributed family is the most important of the five families included in this group; it is also the largest family of living Crinoids.

But according to the latest system of classification adopted by A. H. Clark in his Monograph on the Existing Crinoids, the group Comatulida is considered as an Order by itself and the groups Oligophreata and Macrophreata as Suborders under the Comatulida. This system is, therefore, adopted in the present account, and the synopsis of the characters of these groups (Order Comatulida and Suborders Oligophreata and Macrophreata) are given below:

ORDER COMATULIDA

Pentacrinites in which bassals usually, but not always, metamorphosed into a rosette are present, and the column is either entirely absent, or discarded after the formation of the first nodal columnal, which remains permanently attached to the calyx.

Members of this Order occur in all oceans and seas, excepting the Black Sea and the Baltic, from between tide marks down to a depth of 5301 metres.

SUBORDER OLIGOPHREATA

This is a Suborder of the Comatulida in which the cavity in the centrodorsal containing the chambered organ and overlying structures is very small and shallow; the rosette is sunk below the dorsal surface of the radial pentagon, and both the radial and inter-radial extensions form "spout-like" processes; the central portion of the radial pentagon

is more or less completely filled with an irregular calcareous deposit which forms a central plug, the plane of the muscular fossae on the radial articular faces makes a considerable angle with the dorso-ventral axis, or the muscular fossae are very greatly reduced. The brachials from about the fourteenth onward are usually short, generally much broader than long; the brachial syzygies are usually more or less widely and irregularly spaced; the pinnules, always the proximal and in some groups all, are wholly or in part prismatic with a dorsal carination which may be confined to the earlier segments, segments of the distal pinnules beyond the third not especially slender or elongated, and the first two not appreciably broadened; there are never more than five radials, arms are ten or more in number, very commonly more than ten.

SUPERFAMILY TROPIOMETRIDA

A Superfamily of the Suborder Oligophreata in which all the pinnules are prismatic, triangular in cross-section, with a sharp or sharply rounded, dorsal keel; well developed side and covering plates are usually, though not always, present along the pinnule ambulacra; the arms terminate abruptly, the minute terminal brachials being curved inwards between the fully developed terminal pinnules, which extend for some distance beyond them; all the pinnules are present in all the species.

This superfamily is most strongly represented in the area from southern Japan to Australia.

FAMILY TROPIOMETRIDAE.

In this family the ventral perisome of the pinnules is not protected by conspicuous side and covering plates, and the cirri are stout, without dorsal processes. The species included in this family have normally ten arms only.

This family includes the single genus *Tropiometra*. The pinnules are stout and prismatic (i.e., triangular in cross section), and they bear mostly short pinnulars. This family is also distinguished by the absence of side and covering plates for the ambulacral grooves of the pinnules.

GENUS TROPRIOMETRA A. H. CLARK

This genus is characterized by the presence of ten arms with stout cirri.

This genus is represented by a single species in the Museum collection, namely, *Tropiometra carinata clarki* Gislén (formerly designated as *Tropiometra encrinus* Clark).

TROPIOMETRA CARINATA CLARK & GISLÉN.

FIGURE 1.

Alecto carinata, Leach, Zool. Miscellany, 1815, p. 63.

Alecto encrinus, Lütken, Ms.

Antedon aleutae, Burke (Sci. Trans. Roy. Dublin Soc. 2), Vol. 3, 1887, p. 645.

Antedon marmorata, Carpenter, P. H. "Challenger" Reports, XXVI, Zoology, 1888, p. 202 (nomen nudum).

Antedon sp., Moseley, Quarterly Journal of Microscopical Science, XVII, 1877, p. 8.

Antedon, sp., Mac Munn, Quarterly Journal of Microscopical Science, XXX, 1890, p. 55.

Antedon carinata, (part) (not of Lamarck), Carpenter, P. H. "Challenger" Reports, XXVI, Zoology, 1888, p. 199.

- Tropiometra carinata*, (part) Clark, A.H., Smiths, Miscell. Coll (Quarterly issue), Vol. 50, part 3, 1907 p. 349.
- Tropiometra carinata*, (part), Clark, A.H., Vidensk. Medd. fra den naturhist. Forening i Kobenhaven 1909, p. 182.
- Tropiometra carinata*, Clark, A.H., "Recent African Crinoids", Proc. United States National Museum, Vol. 40, 1911, p. 36. (in part, East Coast of Africa).
- Tropiometra encrinus*, Clark, A.H., "The Crinoids of the Indian Ocean" (Echinodermata of the Indian Museum, Part VII), Calcutta, 1912, p. 177 and p. 178, fig. 29.
- Tropiometra encrinus*, Clark, A.H., Records of the Indian Museum, XXXIV, Part 4, 1932, p. 560. (Pamban Beach, Madras, Waltair).
- Tropiometra encrinus*, Gravely, "Shells and Other Animals Remains of the Madras Beach", I, Groups other than Snails: Bull. Mad. Govt. Mus., New Series, Nat. Hist., V.No. 1, 1941 p. 86 and p. 105.
- Tropiometra carinata clarki*, Clark, A.H., "A Monograph of the existing Crinoids", Bull. United States National Museum, No. 82, Vol. I, Part 4b, 1947, p. 281, pl. 34, figs. 175-177; pl. 35, figs. 180-182.

This species has previously been recorded from the Madras harbour by Dr. Gravely (*loc. cit.*, 1941). It is a purplish brown Crinoid, with ten feather-like arms. The animal becomes detached from its stalk in the early stages in its life history and hence can move about in adult life. The cirri are about twenty-three to twenty-six in number (usually twenty-five) and are about 21 to 22 millimetres long each. They have 26 to 29 segments each. The cirri are on the whole rather slender and weak, but numerous and arranged in two and a partial, very irregular third and marginal row. This subspecies is closely related to the typical form, *Tropiometra carinata carinata* and *Tropiometra picta* (both of these being found in islands off the coasts of Africa); but *Tropiometra carinata clarki*, while having the same number of cirrus segments as in these two forms has proportionately longer and stouter cirri than in those two species, the stoutness being specially evident in the distal portions of the cirri. The outer segments are about twice as broad as long as in *Tropiometra carinata*, and the last four taper rather rapidly.

The carination of the arms is slight in the proximal half, and entirely absent or only very faintly indicated in the distal half; the cirri are rather large, XX-XXXIII (usually about XXV), 19-34 (averaging 25), and from 20 to 35 (averaging 24 millimetres long), the arms are up to 180 millimetres in length, though rarely exceeding 150 millimetres.

The centrodorsal is a thin to rather thick disc with the broad dorsal pole 5-6 millimeters in diameter, flat or slightly concave, more or less marked with faint radiating lines, and towards the periphery, raised at the bases of the larger cirri. The cirri are arranged in one and a partial second, two, or two and a partial third, marginal rows.

The cirri are XXV, 29-34 (usually 32-33), and from 30 to 35 millimetres long. The first segment is very short, usually a thin disk from six to eight times as broad as long, and the second is about two to two and half times as broad as long. The cirri may remain uniform in width, viewed edgewise, upto the last six or eight segments, after which they taper to the tip, or they may taper very gradually in the distal half, third or fourth. The radials are just visible beyond the rim of the centrodorsal, or they are

concealed in the mid-radical line. The ten arms are about 180 millimetres in length. The first two brachials are markedly larger than those succeeding. The first brachials are wedge-shaped while the second brachials are triangular. The distal ends of the brachials are marked with exceedingly fine longitudinal striations, and the distal edges are very finely spinous.

Pinnule 1 is about 15 mm. long, moderately stout and composed of 25 segments and pinnule 2 is also of the same length as P 1 and is composed of 25 segments. It resembles P 1, but tapers more gradually so that it appears somewhat stouter in the distal half. P 3 is about 15 mm. long, composed of 26 segments, slightly stouter than P 2 and with a somewhat more prominent dorsal crest and with the distal ends of the segments on the side toward the arm base slightly produced.

The disc is about 25 mm. in diameter and is not incised. The five ambulacral grooves running from the mouth usually branch about half way between the mouth and the periphery of the disk, though sometimes nearer the latter.

The colour of the specimens of this species in alcohol is purplish brown with the arms in the outer half or two-third narrowly and profusely banded with dull orange yellow. A.H. Clark (*loc. cit.*, 1947, p. 281) based his very detailed description of this species upon five specimens collected from near Mandapam and on the Pamban beach in the Gulf of Manaar. He also reports several specimens of this species from Madras and Waltair.

This species has been recorded from the Red Sea, Aden, East Indies, Muscat, Indian Ocean, East Coast of Asia, Java, Tor, Tuticorin in Madras State, Ceylon and Norfolk Island. It has also been doubtfully recorded from Suez. The recorded localities for this species also include Pamban beach, Ramanathapuram District, where they have been found in dead coral; near Mandapam, Madras Harbour and Waltair.

It is primarily a littoral species, but has been recorded up to a depth of about 40 fathoms.

On the Madras Coast, this species is common in the Madras Harbour. In alcohol, the preserved specimens are a dull greyish or purplish black or purplish brown.

Specimens in the collection:—Two spirit-preserved specimens, one large and another smaller, probably immature one, collected from the Madras Harbour, are represented in the reference collection of the Museum. They are dull greyish black, and are far too brittle to permit detailed examination. The ten feather-like arms, with a series of pinnules on each side, are purplish brown, with conspicuous dark band-like markings. The cirri are pale brownish.

Measurements: Larger specimen:

Length of arm: 80 mm.

Length of cirrus: 14 mm.

Smaller specimen:

Length of arm: 58 mm.

Length of cirrus: 12 mm.

Superfamily MARIAMETRIDA

This is a Superfamily of the Suborder Oligophreata, in which there is no comb-like structure on the distal portion of the oral pinnules; the distal pinnules are never prismatic and the genital pinnules are also never prismatic, though occasionally a few of the basal

segments may be carinate; the oral pinnules, which may be long or short, slender or stout, or stout basally and slender distally, varying from very flexible to stiff and spine-like condition, composed of long or short segments, usually show some distinct trace of carination on more or fewer of the basal segments, and are sometimes sharply prismatic throughout; and the mouth is always central or subcentral, the anal tube being more or less marginal. Sacculi are always present, though often in small numbers. The arms vary from 5 to 100 in number, but are usually between 15 and 40, and not uncommonly only 10 in number.

Family MARIAMETRIDAE

The arms are always more than ten in number. The peristome of the disk is most commonly naked, but sometimes there are more or less conspicuous scattered thick plates or concretions, which may be more or less contiguous, especially along the ambulacral grooves, or the disc may be almost or quite completely plated. The lateral peristome of the pinnules usually contains simple, more rarely forked or multiradiate spicules, between which and the edge of the pinnulars there may be small, straight spicules or small rods, but calcareous deposits are usually wholly absent.

This family includes multibrachiate Comatulids with two secundibrachs.

A single species of this family, belonging to the genus *Lamprometra*, namely *Lamprometra palmata*, is represented in the Museum collection. Originally this species was referred to the genus *Antedon* and termed *Antedon palmata* (Bell, Proc. Zool. Soc. London, 1882, pp. 533, 534). Later, A.H. Clark referred it to the genus *Dichrometra* under the subfamily Mariametridae of the family Himerometridae and described as *Dichrometra* (Clark, A.H., "Recent African Crinoids", Proceedings of the United States National Museum, Vol. 40, 1911, p. 27). Subsequently the subfamily Mariometridae has been treated as a family, namely, Mariometridae and the present species referred to the genus *Lamprometra* under the family Mariametridae, and designated as *Lamprometra palmata*.

Genus *Lamprometra* A.H. Clark.

In this genus the second pinnule (P 2) is the longest pinnule, usually much longer than the third (P 3) and tapers gradually to a slender and delicate tip. The division series are usually in very close lateral contact with more or less broadly and sharply flattened sides, more rarely just in contact with the sides, slightly or not at all flattened; the cirri are rather short with not more than 30 segments, of which the outer are carinate, rarely more or less spinous dorsally; and the dorsal surface of the division series is smooth, without ornamentation.

A single species, *Lamprometra palmata* (J. Muller), is represented in the Museum collection.

Lamprometra palmata (J. Muller).

FIGURE 2.

Comatula (Alecto) palmata, (part), Muller, J., Abhandl. d.k. preuss. Akad. d. Wiss. 1847, p. 261.

Comatula dividua, Dujardin and Huce, Hist. Nat. des Zoophytes. Echinodermes, 1862, p. 208 (nomen nudum).

Comatula polyactinis, Ibid., p. 208 (nomen nudum).

Comatula protectus, Lutken, Cat. Mus. Godeffr., Vol. V, 1874, p. 190 (nomen nudum).

- Antedon protectus*, Carpenter, P.H., Trans. Linnaean Soc. (Zoology), (2), Vol. II, 1879, p. 19.
- Antedon brevicuneata*, Carpenter, P.H., Notes from the Leyden Museum, Vol. III, 1881, p. 187.
- Antedon brevicuneata*, Hartlaub, Nova Acad. Actd. German, Vol. 58, 1891, No. 1, p. 68, pl. 3, fig. 311 pl. 4, fig. 39.
- Antedon protecta*, Carpenter, P.H., Notes from the Leyden Museum, Vol. III, 1881, 192.
- Antedon protecta*, Carpenter, P.H., "Challenger Reports" Vol. 26, Zoology, 1888, p. 225.
- Antedon protecta*, Hartlaub, Nachr. Ges. Gottingen, Mai, 1890, p. 180.
- Antedon aequipinna*, Carpenter, P.H., Journ. Linnaean Soc., London, (Zoology), Vol. XNI, 1882 p. 504.
- Antedon imparipinna*, Carpenter, P.H., Ibid., p. 505.
- Antedon imparipinna*, Hartlaub, Nova Acta Acad. German, Vol. 58, 1891, No. 1, p. 63.
- Antedon conjungens*, Carpenter, P.H., "Challenger Reports", Vol. 26, 1888, Zoology, p. 233, pl. xlv, fig. 1.
- Antedon palmata*, (part), Bell, Proc. Zool. Soc. London, 1888, pp. 384, 387.
- Antedon palmata*, Thurston, Bulletin, Madras Government Museum, (Old Series), No. 1, 1894, p. 28; No. 2, p. 114.
- Antedon indica*, Bell, Willey's Zoological Results, Vol. II, 1889, p. 133.
- Antedon amboinensis*, Hartlaub, Nachr. Ges. Gottingen, Mai, 1890, p. 181.
- Antedon okelli*, Chadwick, Report of the Ceylon Pearl Oyster Fisheries, Part 2, 1904, Supplementary Report, XI, p. 155, pl. figs. 3-5.
- Dichrometra protectus*, Clark, A.H., Proc. Biol. Soc. Washington, Vol. 22, 1909, p. 13.
- Dichrometra protectus*, Vidensk. Medd. fra dan. naturalist Forening i Kobenhavn, 1909, p. 172.
- Dichrometra protectus*, Clark, A.H., "Recent African Crinoids", Proc. United States National Museum, Vol. 40, 1911, p. 26.
- Antedon palmata*, Chadwick, Report on the Crinoidea of the Sudanese Red Sea, Journ. Linnaean Soc. London, (Zoology), Vol. XXXI, 1907-1915, p. 47.
- Dichrometra protectus*, Clark, A.H., "The Crinoids of the Indian Ocean", (Echinodermata of the Indian Museum, Part VII), Calcutta, 1912, p. 143 and p. 145, fig. 17.
- Lamprometra palmata*, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum, I, No. 1, 1941, p. 86 and p. 105.
- Antedon palmata*, Clark, A.H., "A Monograph of the Existing Crinoids", United States National Museum Bulletin, 82, Vol. I, Part 4 a, 1941, p. 474, pl. 53, figs. 243 to 246.

This species has numerous, usually thirty to forty arms. There is considerable variation in the size of the proximal pinnules. In some specimens the cirri and the lower pinnules are rather small and weakly developed while in others the lower pinnules are large and stout, with the pinnules on the inside and outside of the arms being markedly different from each other.

In specimens preserved in alcohol, the ossicles of the calyx and the proximal brachials are usually of a dirty white colour and the armlets are broadly and alternately banded with the same dirty white colour and dark brownish grey. The dorsal and ventral faces of the ciri show the same contrast of colour. Some specimens are of a uniform purplish black colour.

Lamprometra palmata is always easily distinguished from all other Comatulids, but at the same time it is the most variable species known, and no two individuals are scarcely exactly alike. It has one or more of the proximal pinnules either enlarged or strongly carinate. The cirri are usually carinate dorsally on the distal segments, but these may be rounded dorsally, or they may bear more or less conspicuous spines. The earlier (proximal) segments may be broader than long, like the distal, or as long as, or even longer than broad, and markedly longer than the distal segments. The post-radial series may be in close lateral opposition and broadly and sharply flattened laterally, or quite separated, without any trace of lateral flattening, or in any intermediate condition. P2 is always the longest or the stoutest pinnule, but its size and thickness varies greatly. The proximal pinnules may be approximately of equal size on all the arms or much larger and longer on the outermost arms following I Br. axillary than on the other arms, or they may be enlarged, or elongated, or both, on the outermost arms following each II Br. axillary.

Clark, A.H. (*loc. cit.*, p. 474) distinguishes two distinct varieties of this species. The form with very slender lower pinnules is distinguished as *Lamprometra palmata gyges*, while the typical form is *L. palmata palmata*. The former has a distinctive geographical range, being known from Northern Australia south to Cape Hillsborough, Queensland, and Abrolhos Islands and possibly Perth and Western Australia; while the typical form ranges from Hongkong and Philippines to Carolina, Marshall and Hawaiian Islands, Fiji, Tonga Islands, New Caledonia, Solomon Islands, Torres Straits, westward to Baluchistan. The specimens from the Madras Harbour and Rameswaram, Gulf of Manaar, represented in the Madras Museum collection, belong to the typical form, *Lamprometra palmata palmata* (J. Muller).

In *L. palmata palmata* P2 is markedly stouter than the proximal pinnules. Though it is exceedingly variable in all its characters, the superior length and stoutness of P2 make *Lamprometra palmata palmata* an easy form to recognize when typically developed.

The centro-dorsal varies from a thin disc about 3 mm. in diameter to a thick disc with more or less strongly sloping sides 6 mm. in diameter. It is usually large 4-6 mm. in diameter, thick, discoidal, with moderately sloping sides and with the ciri arranged in two or three (or even a single) irregular marginal rows. The bare dorsal pole is usually more or less strongly convex, more rarely flat, or even slightly concave.

The cirri are XVIII-XLVI (usually about XXX), 20-30 (usually 20-25), and 12 to 25 (usually 15 to 30) mm. long. They vary from slender to stout. The segments may be all sub-equal and all broader than long. The segments in the distal half of the cirri are more or less strongly compressed laterally and are usually more or less sharply carinate dorsally, rarely bearing slightly or moderately developed dorsal spines.

The radials are either entirely concealed by the centro-dorsal or their antero-lateral angles are more or less extensively visible in the interradial angles of the calyx.

The arms are 23 to 51 (usually 30 to 40) in number, 40 to 125 (usually between 55 and 80) mm. long. They may be short and composed of only about 100 brachials, or elongated, with about 170 brachials. Usually they are of moderate length and consist of about 150 brachials. The dorsal surface of the arms is usually more or less rugose basally but is otherwise smooth and is often smooth throughout. The arms may taper gradually from the base to the tip or they may increase slightly in width up to about the 14th brachial, and from there tapering distally. Low and more or less obscure articular tubercles are usually, though not always, present on the arm bases.

The lower pinnules may be approximately equal on all the arms, but usually those on the outer side of the outmost arms of each postradial series, especially P2, are more or less, or often greatly, larger than the others.

The disc in the typical adult specimen is about 10 to 20 mm. in diameter and is naked and more or less deeply, often very deeply, incised.

This species is essentially a littoral form and has been found only in shallow water, being recorded up to a depth of 12 to 36 fathoms.

This species has a wide range of distribution having been recorded from Ceylon, Port Blair (Andaman Islands), Fiji, Zamboanga, Cebu, Philippine Islands, Carolines, New Caledonia, Java, Johore Strait, New Guinea, New Britain, Cochin China, Hong Kong, Singapore, Red Sea, Suez Bay, Suakin Harbour, and Rameswaram Island, Gulf of Mannar.

On the Madras Coast, it has been recorded from the Madras Harbour (Gravelly loc. cit., 1941).

Specimens in the collection. A single, very fragile and brittle, dry-preserved specimen, from Pamban, Gulf of Manaar (originally labelled as "*Antedon palmata*") is represented in the Museum collection. It is uniformly dull greyish brown; presumably it has faded into this colour from a uniform purplish brown during life. There are five primary arms, each of which divides near the base into two and these again into two twice, so that there are really forty arms. The length of each of these branches of the arms is about 45 to 50 mm.

SUBORDER MACROPHREATA.

This is a suborder of the Comatulida in which the central cavity in the centro-dorsal containing the chambered organ and overlying structures is large; the rosette is not sunken below the dorsal surface of the radial pentagon, and the interradial extensions do not form "spout-like" processes; or the radials may be essentially unmodified (Atelecrinidae); there is no calcareous deposit on the inner surface of the radials nor upon the central surface of the rosette, so that there is no trace of a central plug; the plane of the muscular fossae on the radial articular faces is nearly or quite parallel to the dorso-ventral axis of the animal, so that the muscular fossae are separated from the very large central cavity only by thin calcareous lamina which are quite different from the more or less thick wedges seen in the Oligophreata; the joint face elements distal to the transverse ridge are strongly excavated, especially interiorly, so that they meet in the median dorso-ventral line at an angle of usually 90° ; the brachials from the second syzygy onward are usually triangular or very obliquely wedge-shaped; the second brachial syzygy is usually between brachials 9 plus ten (Antedonidae and Pentametrocrinidae) or 6 plus seven (Atelecrinidae); the distal brachial syzygies are evenly and closely spaced; the pinnules are all cylindrical or more or less flattened, never prismatic, and without a dorsal carination; in the distal pinnules the first two segments are broadened and those beyond the third are elongate; the radials are usually five, but in two genera ten; and the arms with very rare exceptions are 5 or 10, or in species with 10 radials, 10 or 20.

Family ANTEDONIDAE.

A family of the Suborder Macrophreata in which the basals are transformed into a rosette; there are 5 (in one genus 10) radials each of which bears a I Br. series and 2 arms (II Br. series being only very exceptionally present); and the gonads are developed wholly within the pinnules.

This is the largest and most important family of the living Crinoids. It comprises about 46 genera and over 130 species. It includes mostly ten-armed species; the outer pinnules are very slender and delicate. The brachials are wedge-shaped and the syzygies are regularly spaced. The Antedonidae are cosmopolitan in distribution occurring on all shores and at all depths ranging from the inter-tidal zone up to a depth of 6,000 metres. These are the commonest Comatulids found outside the limits of the tropical regions.

The specimens of this family represented in the Museum collection belong to the genus *Antedon* which is included in the Subfamily Antedoninae.

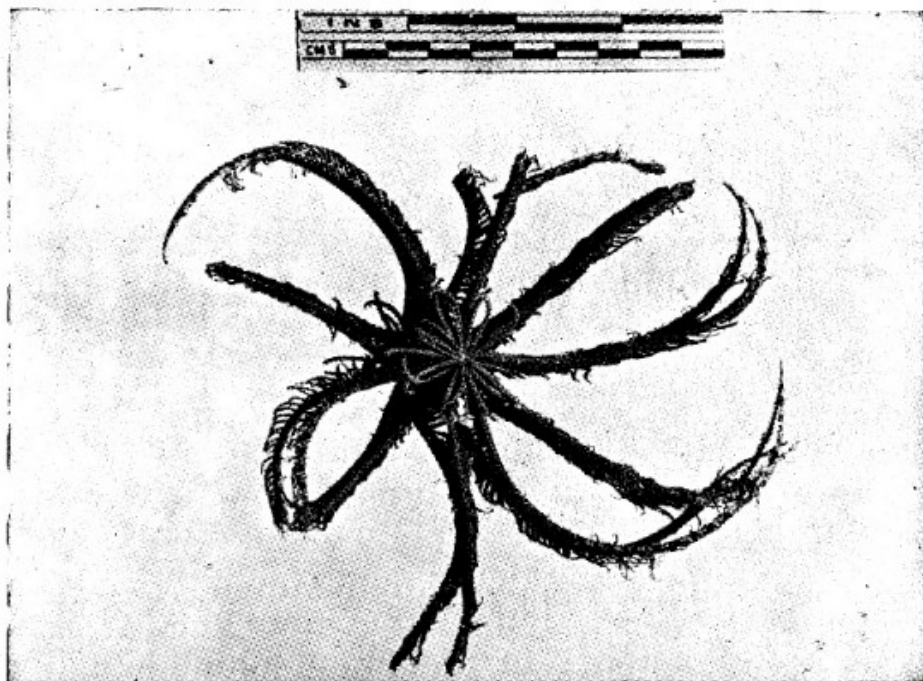


Fig. 1. *Tropiometra carinata clarki* Gislén.
(=*Tropiometra encrinus* Lutken).

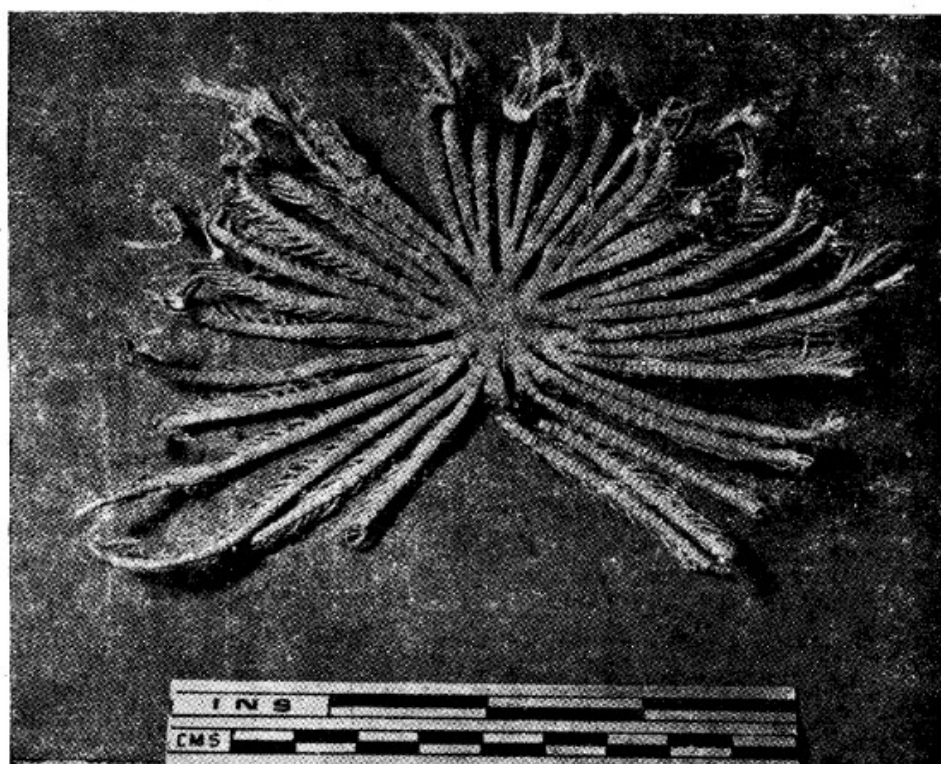


Fig. 2. *Lamprometra palmata* (J. Müller).

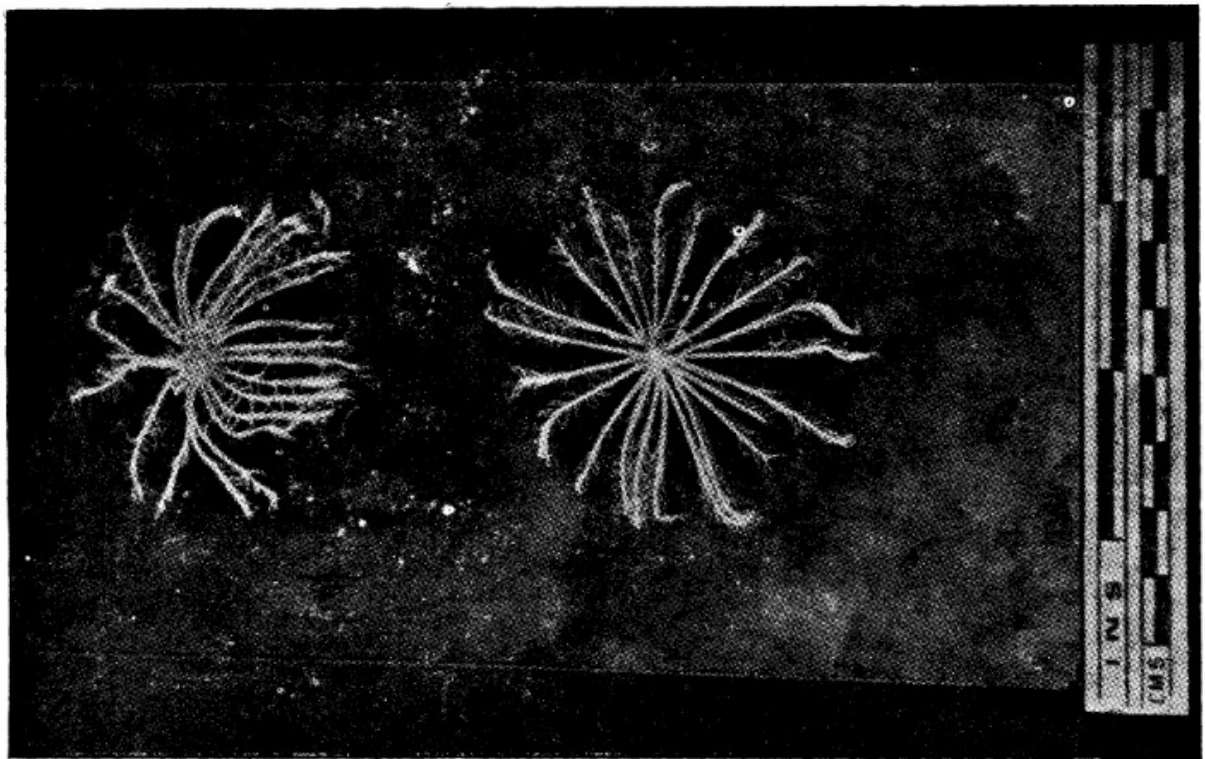


Fig. 3. *Antedon* sp.

Subfamily ANTEDONINAE.

A subfamily of Antedonidae in which the cirrus sockets are closely and irregularly crowded or arranged in more or less regular alternating transverse rows (never in columns) on a discoidal to hemispherical or even rounded, conical centro-dorsal; the cirri, though of very variable length, are usually short with rarely more than 25 and never with more than 33 segments of which the distal are entirely without dorsal spines or other processes except for the opposing spine, which is rarely absent; and is rarely composed wholly or mostly of numerous short segments. The segments of the genital pinnules are never expanded.

The best known genus of this Subfamily is *Antedon*, which includes mostly European and Mediterranean species.

Genus *Antedon* De Framinville.

In this genus P3 resembles the succeeding pinnules and bears a gonad; P1 is usually about half as long as P1 and resembles P3 and may or may not bear a gonad; sometimes P2 resembles P1 when that pinnule is composed of more than 25 segments, but then it is always less than two-thirds as long with less than four-fifths as many segments.

Antedon sp.

FIGURE 3.

A few unidentified specimens labelled *Antedon* sp. are represented in the Museum collection.

Two well preserved specimens of *Antedon*, labelled *Antedon* sp. are mounted in alcohol and displayed in the Gallery. These are from Tuticorin.

Two other unidentified specimens of *Antedon*, labelled as *Antedon* sp. from an unknown locality are represented in the Reference collection. Besides, there are also some other unidentified specimens of Crinoids, probably belonging to the genus *Antedon*, collected from Mandapam, Ramanathapuram District, in the Reference collection. However, as all these specimens are extremely fragile and delicate, being very brittle and breaking into pieces at the slightest touch, it had not been possible to subject them to close study and examination which correct identification will necessitate.

SUBPHYLUM ELEUTHEROZOA.

This Subphylum includes stemless, free-living Echinoderms, with the mouth on the lower surface. They normally rest and move with the oral surface downwards, or lie on one side. The structure is usually radially symmetrical and predominantly pentamerous. The ambulacral system typically serves a locomotory function and is generally not food-gathering. The anus, when present, is usually on the aboral surface. The main nervous system is oral.

This Subphylum comprises Echinoderms in which the theca or test, which may, sometimes be rigid, but sometimes only slightly calcified or flexible, is not attached to any substratum by any portion of its surface, but is usually placed with the oral surface downwards or in the direction of forward locomotion. The circumoesophageal water vascular ring may sometimes lose its connection with the exterior altogether. The podia may be either locomotor, respiratory or sensory in function.

This Subphylum includes all the remaining four Classes of Echinoderms which comprise the vast majority of living Echinoderms and which are more advanced in several respects than the comparatively more primitive Crinoids and their allies included in the Subphylum Pelmatzoa.

CLASS HOLOTHUROIDEA.

This Class comprises soft bodied Echinoderma normally elongated in the oro-anal or oral-aboral axis with a bilateral symmetry which has been secondarily attained. These animals usually lie on one side which may be differentiated from the side away from the substratum. The mouth is surrounded by a circlet of tentacles attached to the water vascular system. The integument is tough, leathery and coriaceous. The calcareous endoskeleton may be entirely absent, but is usually represented by minute, almost microscopic spicules or plates embedded in the body wall. The podia are in the form of locomotory tube feet, sometimes wanting. In addition to these, simple papillae may also be present. The podia usually lie along the five ambulacral areas, but may be spread over the entire surface. The gonads are not radially arranged and are composed of a single or paired tuft of tubules.

There are about five hundred known species of Holothurians. They are popularly known as the sea cucumbers and are of sluggish habits, remaining sedentary for long periods. They are, in general, benthonic animals lying passively on the bottom of the sea. Some live on a rocky bottom, while others prefer a sandy bottom, where many species lie partly or wholly buried in the soft sand or mud. They have been known to man from ancient times and some of them are economically important as they are used in the manufacture of *trepan* or *beche-de-mer*.

ORDER DENDROCHIROTAE.

This Order includes Holothurians with numerous podia, and is characterized by the presence of dendritic oral tentacles that are not provided with conspicuous ampullae. Oral retractors and respiratory trees are present. The podia are present either over the entire body or they may be confined to the ambulacra. The gonadal tubules are arranged in two tufts, one on either side of the dorsal mesentery.

The species of this Order represented in the Museum collection belong to three families, namely, Cucumariidae, Psolidae and Phyllophoridae, all of them being included in the Superfamily Dendrochirotae.

These three families of the Superfamily Dendrochirotae are represented in the Museum collection by species belonging to the following seven genera. It may be noted there that the members of the families Psolidae and Phyllophoridae were also formerly included in the family Cucumariidae.

1. Genus *Psolus* (Family Psolidae).
2. Genus *Stolus* (Family Cucumariidae).
3. Genus *Thyone* (Family Cucumariidae).
4. Genus *Cucumaria* (Family Cucumariidae).
5. Genus *Actinocucumis* (Family Cucumariidae).
6. Genus *Pentacta* (*Cholochirus*) (Family Cucumariidae).
7. Genus *Phyllophorus* (or *Orcula*) (Family Phyllophoridae).

The above genera may be distinguished from one another with the aid of the following key, which is more or less based on the key furnished by Dr. Gravely in his report on the Echinodermata of Krusadai Island (The Littoral Fauna of Krusadai Island, in the Gulf of Manasar, *Bulletin of the Madras Government Museum, Natural History*, I, No. 1, 1927, pp. 165—166).

- | | |
|---|-----------------|
| 1. Ambulacral appendages confined to a distinct ventral creeping sole | <i>Psolus</i> , |
| —Animal without a distinct creeping sole | 2. |
| 2. Pedicels scattered all over the body— | 3. |
| —Pedicels more or less completely confined to the radii | 5. |

- | | |
|--|-------------------------|
| 3. Tentacles ten | 4. |
| —Tentacles arranged in two crowns, twelve to sixteen in the exterior and five to six in the interior .. | <i>Phyllophorus</i> . |
| 4. Body wall thick and rigid; only buttons are present in the body wall and retractile tube feet .. | <i>Stolus</i> . |
| —Body wall thin and flexible; both pedicels and tube feet are found scattered over the entire surface of the body | <i>Thyone</i> . |
| 5. Tentacles ten | 6. |
| —Tentacles eighteen to twenty | <i>Actinocucumis</i> . |
| 6. Ambulacral appendages of two kinds, namely, pedicels and papillae, the latter often situated on tops of warty protuberances | <i>Pentacta</i> . |
| | (= <i>Colochirus</i>). |
| —Ambulacral appendages only in the shape of pedicels forming one or two more rows along each ambulacrum. | <i>Cucumaria</i> . |

According to the earlier classification, followed by Théel, in his Challenger Reports on Holothuroidea ("Holothuroidea" II, Rep. Sci. Res. H.M.S. "Challenger", Zoology, XIV, 1886), all the above genera were included in the main family Dendrochirotae, but they were grouped under different subfamilies under Dendrochirotae as follows:

The genera *Cucumaria*, *Pentacta* (= *Colochirus*) and *Actinocucumis* were included in subfamily I, Stichopoda, the genus *Psolus* in subfamily II, Gastropoda, and the genera *Stolus*, *Thyone* and *Phyllophorus* (and the allied genus *Orcula*) in subfamily III, Sporadipoda.

Since, however, according to the latest classification followed by Hyman in her volume on Echinodermata (in the series on Invertebrata) and adopted in the present account, the family Dendrochirotae has actually been split up into three families, namely, Cucumariidae, Psolidae and Phyllophoridae, and, according to this classification, the genera *Cucumaria*, *Thyone*, *Stolus*, *Actinocucumis* and *Pentacta* (= *Colochirus*) are grouped in the family Cucumariidae, the genus *Psolus* in the family Psolidae and the genus *Phyllophorus* in the family Phyllophoridae, the family Cucumariidae of this later classification roughly corresponds to the subfamily Stichopoda of the earlier classification, the family Psolidae to the subfamily Gastropoda and the family Phyllophoridae to the Subfamily Sporodipoda of the earlier classification.

In the following account, therefore, it has been considered desirable to mention the characters of the corresponding subfamilies of the older classification as well side by side with the characters of the corresponding newly established families of the later classification.

Superfamily DENDROCHIROTAE.

The tentacles are dendriform. Retractor muscles are present. The mouth and anus are at the opposite poles of the body.

Family CUCUMARIIDAE.

(Corresponds to the Subfamily STICHOPODA of the earlier classification).

The ambulacral appendages are in the shape of pedicels alone, or pedicels together with papillae, the latter often placed on larger or smaller processes; they are mostly arranged in rows, on the dorsal as well as the ventral ambulacra; the interambulacra are

mostly naked. The tentacles are ten in number, rarely eighteen, twenty or twenty-four. The calcareous ring is composed of ten pieces, which usually are simple and devoid of prolongations posteriorly.

Genus *Cucumaria* Blainville.

The tentacles are ten in number, rarely of equal size, two ventral, commonly smaller. The ambulacral appendages are almost always in the form of pedicels forming one, two or more rows along each ambulacrum. The pedicels are seldom found also on the interambulacra. Deposits are highly variable, very rarely in the shape of reticulate scales.

Two species of this genus are represented in the Museum collection, namely, *Cucumaria conjungens* Semper and *Cucumaria frauenfeldi* Ludwig,—both from Pamban. The former is by far the commoner and better known of the two and may be distinguished by its brownish colour in life while the latter is pale pink with dark brown tentacles in life.

Cucumaria conjungens Semper.

FIGURE 4.

Cucumaria conjungens, Semper, "Holothurien", Reisen im Archipel der Philippinen (2) I (Weisbaden), 1868, pp. 51 - 52; pl. vi, fig. 5. pl. xiii, fig. 7; pl. xiv, fig. 4.

Cucumaria conjungens, Theél, "Holothuridea", Part II Rep. Sc. Res., H.M.S., "Challenger", Zoology XIV, 1886 p. 112.

Cucumaria conjungens, Pearson, Report on the Holothuriodea collected by Professor Herdman at Ceylon, Ceylon Pearl Oyster Fisheries Report, pt. I, Supplementary Report, V, 1904, p. 191.

Cucumaria conjungens, Gravely, Littoral Fauna of Krusadai Island in the Gulf of Mannar, Bull. Madras Govt. Mus., Natural History (New Series), I, No. 1, 1927, p. 107.

This is a small species of Holothurian, two specimens of which, collected at Pamban, are represented in the Museum collection. It was first described by Semper from the Philippine Islands (*loc. cit.*), and has since been recorded also from Ceylon (Pearson, *loc. cit.*).

The body is cylindrical, rounded or truncated anteriorly, and rather sharp and tapered posteriorly. Both the interambulacra of the *Trivium* bear numerous small tube feet, scattered in a rather irregular manner as in *Thyone*. The three interambulacra of the back (dorsum) are devoid of tube feet. The ventral pedices are numerous, irregularly dispersed over the ambulacra and interambulacra; the dorsal pedicels are only confined to the ambulacra, where they form two or three rows. In the radii the tube feet are found in two to three not very regular rows, the tube feet being very small. Ten tentacles are present. Radial and interradial pieces of the calcareous ring are composed of several smaller parts, the former with two long, articulate posterior prolongations.

The colour is uniformly brownish.

Pearson (*loc. cit.*), commenting on the single specimen from the Pearl Banks, Gulf of Mannar, which he had examined, states that the arrangement of the dorsal pedicels into three rows, as described by Semper in his original description, is not very clearly marked. The pedicels on the ventral surface are much more numerous than the dorsal pedicels and are irregularly scattered, and this conditions is also observed in the Pamban specimen represented in the Museum collection. The body, in the Pearl Bank specimen examined by Pearson, is stated to taper at both ends, being more pointed at the posterior end than at the anterior end.

The deposits consist of tables, resembling buttons, with an oval, knobbed disk, perforated by a few (about four) holes and with a very short spine with two points, according to the original description given by Semper (*loc. cit.*).

Dr. Gravely (*loc. cit.*), who subsequently examined the deposits in the Pamban specimens states that the buttons are of two kinds. Those from the body wall are flat and roughly oval in shape, with knobbed margin. The centre of these buttons bears on one side a trilobed arch, each of the three lobes sometimes bearing a group of small teeth. The buttons from the pedicels are curved and more elongate. They consist of a diamond-shaped centre piece dilated at either end into a more or less circular end piece. They are without knobs and the central arch which is borne on the convex surface is less distinctly trilobed and more strongly toothed.

In the Pamban specimens scattered pedicels are observed to occur on the two lateral interambulacra, as well as on the ventral pair, being indeed less general on the latter than on the former. But the mid-dorsal interambulacrum is entirely free from them.

Recorded localities.—Theel (*loc. cit.*), records this species from Mariveles, Bay of Manila (2 to 3 fathoms). Semper (*loc. cit.*), also cites this locality in his original account Pearson (*loc. cit.*), reports one specimen of this species from Pearl Banks, Gulf of Manaar (Length: 14 mm.). Pearson states that this is recorded from Ceylon for the first time. Later it was recorded also from Pamban (Gravely, *loc. cit.*).

Specimens in the collections.—A single small specimen collected from Pamban in 1925 is represented in the Museum collection. It is rather contracted, dull greyish brown in colour and with conspicuous, large, scattered, wart-likes pedicels on the body disposed more or less as noted above. The body is more or less cylindrical, rounded or truncated anteriorly and somewhat narrowed and tapered posteriorly. The tentacles are contracted.

Measurements: Length: 14 mm.

Width at the middle of the body: 4 mm.

***Cucumaria frauenfeldi* Ludwig.**

FIGURE 5.

Cucumaria frauenfeldi sp., Semper, "Holothurien", Reisen im Archipel der Philippinen (2), I (Weisbaden), 1868, pl. xxxix, fig. 22.

Cucumaria frauenfeldi, Gravely, Littoral Fauna of Krusadai Island, Bull. Madras Govt. Museum, (Natural History), New Series, I, No. 1, 1927, p. 167.

This species closely resembles *Thyone mirabilis* in external appearance. It is pale pink in colour, with dark brown tentacles, during life. Its spicules are stout, curved, smooth rods, with slightly enlarged, perforate and dentate ends. These spicules are abundant in the surface layers of the body wall. Ludwig, in 1882, identified Semper's Javanese specimen with the present species (*Cucumaria frauenfeldi*) which is reported to be a common South African form, but had not been previously recorded from India or Ceylon.

Recorded localities.—Java, South Africa, Pamban, Gulf of Manaar (South India).

Specimens in the collection.—A single specimen from Pamban (collected in 1925), about 40 mm. long (while living), is represented in the Museum collection. Dr. Gravely (*loc. cit.*) reports that it was pale pink in life, with dark brown tentacles, but the preserved specimen in alcohol represented in the Museum collection is rather contracted and uniformly dull greyish brown.

Measurements: Length: 25 mm.

Width at the middle: 14 mm.

The body is covered with rough, wart-like pedicels all over and the tentacles are contracted.

Genus *Stolus* Selenka.

This genus closely resembles the succeeding genus, *Thyone* (with which it has sometimes been confused by early authors), but is readily distinguished from *Thyone* by its thick and rigid body wall, and the presence of only buttons in the body wall and retractile tube feet. Both these genera belong to the subfamily Thyoninae which, according to Panning, is characterized by a calcareous ring composed of a complex mosaic of minute pieces with long posterior processes. The tentacles are ten in number and the tube feet are not confined to the radii but scattered all over the surface of the body.

A single species, *Stolus buccalis* (Stimpson), which is referred to in the earlier Bulletin on the Littoral Fauna of Krusadai Island (Bull. Madras Government Museum. Natural History I, No. 1, 1927) by Dr. Gravely as *Thyone sacellus* and of which it is reported to be a synonym, is represented in the Museum collection.

However, since the name *Thyone sacellus* no longer holds good [vide D. B. James, "Studies on Indian Echinoderms—2: The Holothurian *Stolus buccalis* (Stimpson) with Notes on its Systematic position", *Journal of the Marine Biological Association of India*, 1966, VIII, No. 2, pp. 285-289] this species is described under the name *Stolus buccalis* (Stimpson), which is the currently accepted name, in the present account.

Stolus buccalis (Stimpson).

FIGURE 6.

- Thyone buccalis*, Stimpson, "Descriptions of some new marine Invertebrates", Proceedings of the Academy of Natural Sciences, Philadelphia, VII, (10), 1855, pp. 385-387.
- Thyone buccalis*, Théel, "Report on the Holothurioidea", II, Rep. Sci. Res. H.M.S. "Challenger", Zoology, XIV, 1886, p. 136.
- Thyone buccalis*, Clark, H.L., "Echinoderm Fauna of Australia, its composition and its origin" Carnegie Institute, Washington, 566, 1946, p. 401.
- Stolus sacella*, Selenka, Beiträge zur Anatomie und Systematik der Holothurien, Zeit. f. wiss. Zool., XVII, 1867, p. 355.
- Stolus sacellus*, Panning, Versuch einer Neuordnung der Familie Cucumariidae (Holothurioidea, Dendrochiroidea), Zool. Jb., 78, (4), p. 462.
- Stolus sacellus*, Cherbonnier, G., Resultats Scientifiques des Campagnes de la 'Calypso' I, Campagne en Mer Rouge, 1955, p. 167.
- Thyone rigida*, Semper, Holothurien, Reisen im Archipel der Philippinen (2) I, Weisbaden, 1868, p. 66.
- Thyone sacella*, von Marenzeller, Verz. bot. Ges. Wien, 1881, p. 134.
- Thyone sacellus*, Lampert, Die Seewalzen 1885, p. 154.
- Thyone sacellus*, Lampert, "Gazella", Holothurien, Zool. Jahrb., Bd. IV, p. 834.
- Thyone sacellus*, Bell, Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H. M. S. "Alert", 1881-1882, British Museum, London, 1884, p. 149.
- Stereoderma Murrayi*, Bell, Proc. Zool. Soc. London 1883, Part I, pp. 58 to 62.

Thyone sacella, Theél, "Report on the Holothurioidea", II, Rep. Sci. Res. H.M.S. "Challenger", Zoology, XIV, 1886, p. 138.

Stereoderma Murrayi, Theél, *Ibid.*, p. 142.

Thyone sacellus, Sluiter, "Holothurien", Siboga-Expeditie, XLIV, 1901, (Livr. I, Leiden, 1904), p. 83.

Thyone sacellus, Pearson, "Report on the Holothurioidea collected by Professor Herdman at Ceylon", Ceylon Pearl Oyster Fisheries Report, Part I, Supplementary Report, V, 1904, p. 192, pl-i, figs. 9 and 10.

Thyone sacellus, Ekman, Holothurioidea, Results of Dr. Mjöberg's Swedish Scientific Expeditions to Australia (1910-1913), K. Svenska. Vetensk. Akad. Handl., 58 (6), 1918, p. 42.

Thyone sacellus, Gravely, Littoral Fauna of Krusadai Island in the Gulf of Manaar, Bull. Madras Govt. Mus. Natural History (New Series), 1. No. 1, 1927, p. 166.

Thyone sacellus, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum, Natural History, (New Series), V, No. 1, 1941, p. 91.

Thyone buccalis lourdesae, Domantay, "Littoral Holothurioidea of Hundred Islands and Vicinity, Lingayen Gulf, Luzon Island, Philippines", Philippine Journal of Science, 89 (1), 1951, p. 101.

Stolus buccalis, James, D.B., "Studies on Indian Echinoderms-2. The Holothurian *Stolus buccalis* (Stimpson), with notes on its systematic position", Journal of the Marine Biological Association of India, VIII, (2), 1966, pp. 285-289.

This species is represented in the Museum collection by several specimens from Pamban, Rameswaram and Madras. Dr. F.H. Gravely, in his account of the Echinodermata of Krusadai Island (*loc. cit.*, p. 166) makes mention two specimens of this species from Pamban, a very small one from the Museum collection, and one, much larger, measuring about 70 mm. long from an older collection. Both are reported to be white in colour in spirit, but the colour in life was not noted. However, Theél (*loc. cit.*, p. 143), states that *Thyone sacellus* is of a dark brown colour in life and has 4 polian veicies and 12 to 20 madreporic canals.

The body is nearly cylindrical, strongly wrinkled, about 50 to 75 mm. long and 7 to 8 mm. in diameter in the adult specimen. The podia are completely retractile, and are not densely arranged, as is generally found in the species of this genus. The tentacles are very small. The body is rendered rather stiff and rigid owing to the presence of numerous calcareous bodies (buttons) in the integument or body wall; hence the synonymous specific name, *Thyone rigida*, is sometimes employed for this species. The calcareous ring is made up of ten pieces, which are in turn made up of many single segments. The radials are prolonged, and extend into two limbs or branches enclosed by radial vessels.

As mentioned earlier, Theél (*loc. cit.*, p. 143) reports that the colour of *Thyone sacellus* (which is a synonym for *Stolus buccalis*, in life is dark brown; Semper (*loc. cit.*, p. 66) states that this species is brownish grey in colour during life, while Pearson (*loc. cit.*, p. 192) records that the colour of this species in spirit is light yellow, with irregular brown spots. It is probable that there is a certain amount of colour variation among specimens of this species collected from different geographical regions.

Pearson (*loc. cit.*, p. 192) reports that the pedicels in this species are irregularly scattered all over the body. They are very small and numerous, showing a regular arrangement in three double rows on the trivium. These rows are not contained to the extremities, but are confined to the middle of the body.

The deposits consist of numerous, somewhat irregularly shaped, button-like bodies which are very much like those of *Psolus complanatus* but which have the central knobs horizontally perforated at the base. Typically, these buttons consist of a plate with four holes and a smaller half ring arising from the centre of the plate on each side at right angles thus presenting the view of two half rings placed vertically to one another. In addition to these, Pearson (*loc. cit.*) reports numerous plates having more than four holes and having short spines on the surface (Pearson, *loc. cit.*, pl. i, fig. 10), but such plates have not been found in the Pamban specimens in the Museum collection.

However, Gravely (*loc. cit.*, p. 166) reports that in the larger of the specimens contained in the Museum collection, there are a number of more elongate, smooth, perforated plates which are somewhat variable and irregular in shape; these plates bear a small piece at each end either irregularly perforate or dentate and separated by a constriction from a larger diamond-shaped middle piece with four perforations. In the smaller specimens examined by him only buttons were noticed.

Semper (*loc. cit.*, p. 66) reports that the calcareous bodies of this species resemble greatly those of *Thyone* (*Stolus*) *firma* Salenka, and he has consequently suggested that it might be quite possible that the two are one and the same species, especially in view of the fact that they have been collected in the same area.

Bell (*loc. cit.*, p. 61) described *Stereoderma Murrayi* as a new species based on a specimen from Karachi, but it afterwards turned out to be identical with *Thyone sacellus*. Bell refers to *Stereoderma* as a remarkably firm-bodied genus and describes *Stereoderma Murrayi* as a species with small, dark tentacles, extremely delicate retractors, very long and narrow polian vesicles and with the oesophagus covered with calcareous plating much as in *Thyone sacellus*. The integument is reported to be very thick, and filled with strong-walled firm corpuscles. The skin is described as being white in colour, and the double row of the suckers as being well developed only in the anterior third of the body, but better developed behind than in the middle. The calcareous ring is composed of numerous small plates and carries five long, slender prolongations posteriorly. The deposits consist of numerous, crowded, oval plates with uneven or undulated margin pierced with four holes and provided with lower or higher elevations round margin; on the upper and under surfaces, a half ring is placed so as to form together, a complete smaller ring, vertical in position to the plate itself.

The above description of *Stereoderma Murrayi* is based on a single specimen from Karachi, about 30 mm. long and 11 mm. wide, of the same, or nearly the same, width along its whole extent.

Theél (*loc. cit.*, p. 142) feels almost fully convinced of the identity of the two forms, *Stereoderma Murrayi* and *Thyone sacellus* which supposition is supported by the presence of the thick, hard peristome with its unusually shaped deposits, the characteristic calcareous ring, etc.

Some minor differences, however, exist: *Stereoderma Murrayi* is of a white colour, but this is possibly the result of fading in alcohol, with dark tentacles and has only one polian vesicle (madreporic canals being absent); whereas *Thyone sacellus* is of a dark brown colour, has four polian vesicles and twelve to twenty madreporic canals.

D. B. James (*loc. cit.*, 1966, pp. 285 - 289) records five specimens of this species, two at Rameswaram and three at Mandapam, in the Gulf of Manaar. He records and describes them under the name of *Stolus buccalis* (Stimpson) and states that it is this same species that had been recorded earlier by Dr. Gravely (*loc. cit.*, 1927, 1941) under

the name *Thyone sacellus* (Saltanka) and adds that since this latter name no longer holds good, this species ought to be correctly referred to as *Stolus buccalis* (Stimpson) which is stated to be a synonym of *Thyone sacellus* (Saltanka).

D. B. James (*loc. cit.* 1966, p. 286) reports that the colour of this species in life is light purple, but white in specimens preserved in alcohol. The tentacles are dark. The calcareous ring is described as being complex and composed of a number of pieces. Four types of calcareous deposits are reported by James, as being present in different parts of the skin: (i) small rods with expanded ends, each end with a hole at the centre; such rods are said to be present in the tentacles; (ii) large, oval buttons with twelve knobs and four holes, thickly packed throughout the body wall; (iii) irregular thin buttons with four to many holes found both in the tentacles and the introvert; (iv) large supporting plates found in the tube feet.

However, James doubts the specific identity of the species recorded as *Thyone sacellus* by Pearson (*loc. cit.*), as none of the specimens examined by James himself or by the other authors contained the numerous plates having short spines on the surface as described by Pearson. James therefore suggests that at present it seems best to refer *Thyone sacellus* of Pearson as a doubtful synonym of *Stolus buccalis* till some specimens with similar spicules are collected and described.

Recorded localities.—Bohol, Canal of Laping, 10 fathoms; Japan Torres Strait, Aden, Zanzibar, Mozambique, East Coast of Africa, Karachi and Ceylon. Pearson (*loc. cit.*, p. 192), has recorded two specimens of this species, five miles off Negombo in Ceylon (12 to 20 fathoms); Pamban, Rameswaram, Mandapam, Gulf of Mannar.

Specimens in the collection.—Specimens from Pamban Bridge, Rameswaram and Madras are represented in the Museum collection. Most of these specimens (preserved in alcohol) are whitish, having lost their original colour, but the most recently collected specimen from Pamban Bridge, collected in September 1948, retains much of the original purplish brown colour.

(1) *Pamban Bridge.*—One specimen collected in September 1948. It is the most perfectly preserved specimen of this species in this collection and has the tentacles and podia fairly well extended. It is also the most recently collected specimen of this species contained in the Museum collection. The specimen is rather dark brownish grey with a purplish tinge. The podia are arranged in more or less well defined longitudinal bands. The integument is tough and rigid.

Measurements : Length : 62 mm.

Width at the middle of the body : 18 mm.

A small young specimen from Pamban, greyish white in colour and measuring 16 mm. in length and 7 mm. in width is also represented in the collection.

(2) *Madras.*—Nine specimens—all strongly wrinkled and bearing transverse folds and faded almost into white or greyish white. The specimens are all very rigid and tough and most of them are badly contracted, but in one or two of them the tentacles are well expanded. The surface of the body is rough and presents a pitted appearance. Two of them are rather small, and are probably young specimens.

Measurements : Largest specimen :

Length : 50 mm.

Thickness of the body in the middle : 19 mm.

Smallest specimen :

Length : 28 mm.

Thickness of the body in the middle : 9 mm.

The other specimens are intermediate in size between these two extremes.

(3) *Pambar*.—One large specimen, collected in 1925 and faded completely into a creamy white colour. The tentacles are completely retracted and the surface of the body is not so strongly wrinkled as in the other Madras specimens, and presents a more or less smooth appearance, being only faintly pitted.

Measurements : Length : 64 mm.

Width in the middle : 20 mm.

(4) *Rameswaram*.—One large specimen collected in 1924, similar to the above, but somewhat more rusty brownish white. It is also not appreciably wrinkled and the surface is smooth but more strongly and closely pitted in appearance.

Measurements : Length : 55 mm.

Width in the middle : 13 mm.

Genus *Thyone* Oken, 1815; Semper, 1868.

The tentacles are ten in number, two of them being ventral and smaller. The podia are distributed over the entire body surface without any definite relation to the ambulacra. The pedicels are more or less crowded all over the body; very seldom an arrangement of the pedicels in definite rows along the ambulacra is discernable.

This genus is readily distinguished from *Cucumaria* by the fact that while in *Cucumaria* the podia are arranged in five ambulacral bands with little encroachment into the interambulacral areas, in *Thyone* they are scattered over the entire surface of the body.

A single species, *Thyone mirabilis* Ludwig, is represented in the Museum collection.

Thyone mirabilis Ludwig.

FIGURE 7.

Thyone mirabilis, Ludwig, Beitrage, 1847, p. 17.

Thyone mirabilis, Lampert, Die Seevalzen, 1885, p. 162.

Thyone mirabilis, Holothurien der Gazelle, Zool. Jahrb. IV, p. 835.

Thyone mirabilis, Théel, Holothuridea, Part II, Rep. Sci. Res., H. M. S. "Challenger", Zoology, XIV, 1886, p. 138.

Thyone mirabilis, Koehler, Echinodermes des Iles de la Sonde, Mem. Soc. Zool. de France, pl. viii, 1895, p. 378.

Thyone mirabilis, Sluiter, "Holothurien", Siboga Expeditie, XLVI, 1901, (Livr. I, Leiden, 1904), p. 93, pl. i, fig. 4.

Thyone mirabilis, Gravely, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bull. Madras Govt. Mus. (Natural History) New Series, I, No. 1, 1927, p. 167.

This species closely resembles *Cucumaria frauenfeldi*, being pale pink, with dark brown tentacles, during life. The body is slightly quadrangular, with a row of small warts along the dorsal ambulacra. The ventral pedicels are much more numerous than the dorsal ones. The anus is devoid of calcareous teeth. The calcareous ring is composed of ten simple pieces, the radial with a bifurcate prolongation posteriorly.

The deposits consist of scattered tables, composed of a roundish perforated disk and a spire of two anastomosing rods.

The colour in life appears to be variable. According to Sluiter (*loc. cit.*, p. 93), the animal is, when alive, of the following colour: stomach region, golden red, the back being more brownish red, the tube feet and papillae stone red, with dark tips, and the tentacles dark violet. The distribution of the feet and the papillae as well as the wart-like elevations and also the 4-angled (quadrangular) form of the body are typically the

same as those described by Ludwig and Lampert for the species *Thyone mirabilis*. However, Sluiter (*loc. cit.*, p. 94) had never been able to find any calcareous deposits in his Siboga-Expedition specimens and this was presumably due to the preservation of the specimens in formation. Even the end plates in the podia in his specimens were absent. But even in well-preserved specimens, the calcareous deposits in this species (*Thyone mirabilis*) are very few and scattered.

Recorded localities: Bowen (Ludwig); Port Denison (Bell); Although Dr. Gravely mentions *Thyone mirabilis* in the Bulletin on the Littoral Fauna of Krusadai Island (*loc. cit.*, p. 167) he does not actually record it as having been found at Pamban. But since a specimen of this species from Rameswaram, near Pamban, in the Gulf of Manaar, is now found in the Museum collection, Rameswaram, near Pamban, also has to be included in the list of its recorded localities.

Specimens in the collection: A single specimen collected from Rameswaram, near Pamban, in the Gulf of Manaar, in 1924, is represented in the Museum collection. It is dark brownish, somewhat contracted and wrinkled. The body is more or less quadrangular in outline and the papillae appear to be closely crowded and scattered all over the body, the ventral papillae being much more numerous than the dorsal ones. The tentacles are fairly well extended although strongly twisted. The posterior end of the body is somewhat narrowed and tapered.

Measurements: Length: 52 mm.

Width at the middle 13 mm.

Width near the posterior end: 5 mm.

Height at the middle: 10 mm.

Genus *Actinocucumis* Ludwig.

The tentacles are eighteen to twenty in number, unequal and irregularly disposed, the two ventral being always the smallest. The ambulacral appendages consist of pedicels and papillae, the former being arranged in several (four to six) rows along each ambulacrum and the latter very small. Scattered on the dorsal interambulacra and also among the pedicels on the dorsal ambulacra.

A single species, *Actinocucumis typica* Ludwig, is represented in the Museum collection.

Actinocucumis typica Ludwig.

FIGURE 8.

Actinocucumis difficilis, Bell, Report on the Zoological Collections made in the Indo-Pacific Ocean during the voyage of "H.M.S. Alert", 1881—1882, British Museum, London, 1884, pp. 148—149, pl. ix, fig. 6.

Actinocucumis typica and *A. difficilis*, Théel, "Holothuridea", Part II, Rep. Sci., Res., H. M. S. Challenger, Zool. XIV, 1886, p. 125.

Actinocucumis typica, Sluiter, "Holothurien", Siboga-Expeditie, XLIV, 1201, (Livre. I, Leiden, 1904), p. 142.

Actinocucumis typica, Gravely, "Littoral fauna of Krusadai Island in the Gulf of Manaar", Bull. Madras Government Museum, Natural History, New Series, I, No. 1, 1927, p. 167.

Five specimens of this species from Pamban, two of them old ones labelled "*Actinocucumis difficilis*" and presumably collected by Thurston and identified by Bell were represented in the Museum collection originally, but now only two specimens are present in the collection. Dr. Gravely (*loc. cit.*, p. 167) shares the same view as that

of Théel (*loc. cit.*, p. 125) with regard to the specific distinctness of *Actinocucumis difficilis* and *A. typica* and states that it is doubtful whether the two could be separated as distinct species in view of the wide range of variability of the many characters of this and the other species—a view that appears to have been accepted by Sluiter as in his list of Holothuria recorded from the East Indian Archipelago and neighbouring seas, but not found during the Siboga Expedition, he mentions the latter species (*A. typica*) only (Sluiter, *loc. cit.*, 1901, p. 142).

The body is more or less pentagonal in section. During life, the specimens are brownish grey in colour. The specimens collected at Pamban attain a length of about 70 mm.

Bell (*loc. cit.*, pp. 148-149) himself admits that he has had the greatest difficulty in confirming the specific distinctness of this form (i.e., *Actinocucumis difficilis*) from the typical *Actinocucumis typica* of Ludwig, and details the following as the differences (as noted by him) by which *Actinocucumis difficilis* could be distinguished from *A. typica*. The ambulacral papillae on the dorsal surface are rare, and the suckers are not in more than four rows for each ray. There are also differences in the form of the spicules.

The retractors (in the typical form of *Actinocucumis difficilis*) are inserted rather farther back, being found at about 24 mm. from the anterior end in a specimen 65 mm. long and at 22 mm. in another specimen examined by Bell, 70 mm. long; the genital tubes are shorter in *A. typica*, being not more than 15 mm. long in any specimen examined. The polian vesicles are also reported to be shorter, being only 7.5 mm. long in a specimen of 65 mm. length. The tentacles, which are not always twenty in number, sometimes seem to belong to an outer circle, and others to an inner circle on the disc. The colour of the specimens of *A. difficilis* is said to be light brown in some cases and in others purplish grey.

But those are all minor differences falling well within the range of normal variation within a species and hence it is almost certain that the two species (*A. difficilis* and *A. typica*) are one and the same species, the minor differences noticed being apparently due to geographical variations.

The deposits are very variable and Gravely (*loc. cit.*, p. 168) reports that many of the spicules in the Pamban specimens in the Museum collection examined by him were apparently in an imperfectly developed condition. The simplest of these spicules are in the form of small and delicate smooth plates, more or less oval in shape, as a rule, with one or more small perforations at each end, and between them either a pair of elongate perforations side by side; or two rows of small punctures. These plates are not reported by Bell. There is another variety of spicules which are more abundant and more robust in appearance. These are the knobbed spicules shaped like the figure of eight. In many of them, some of the knobs are united to form arches across the middle line or sometimes longitudinally. The tables are also variable. Their basal plate curves slightly away from the spire; it is slender throughout, broadest in the middle, with one or two perforations, and again enlarged (though to a less extent) at each end with one or two small perforations. The spire is slender and conical, often more or less incomplete. When complete, the apex is solid, often with a transverse perforation and a few small teeth and the four upright bars are united by a single cross piece near their base. When incomplete, the apex may be bifid or solid, or may be absent, leaving only the bases of the upright bars.

The podia of the belly side are found in two clear rows which are separated from each other. On the back are found only ambulacral papillae. The two median tentacles of the belly side are smaller than the other eight. The anus bears calcareous teeth. The body wall is greatly thickened by the presence of an abundance of ossicles.

Recorded localities.—Albany Island, Torres Straits. Quite recently, a specimen of this species has been recorded from Karachi. In south India this species has been recorded from Pamban, in the Gulf of Manaar from where the specimens represented in the Museum collection have been collected.

Specimens in the collection.—(1) Reference collection: Two fairly well preserved specimens, one larger and the other small and probably young, collected from Pamban in 1925 are represented in the Museum's Reference collection. The body is more or less pentagonal in outline, the rows of thick, conical pedicels being confined to the angles of the body (i.e., along each ambulacrum) through out their entire length. The tentacles are about twenty in number, and are fairly well extended in the present specimens. The colour of the specimens in spirit is dull greyish but the tentacles are brownish white. The posterior end is somewhat narrowed in both specimens.

Measurements :

Larger specimen : Length : 50 mm.
 Width at the middle : 13 mm.
 Height at the middle : 10 mm.
 Smaller specimen : Length : 32 mm.
 Width at the middle : 8 mm.
 Height at the middle : 6 mm.

(2) Gallery collection: One moderate-sized specimen faded almost into a dirty greyish white, with the tentacles fairly well extended, is exhibited in the gallery. The rows of suckered papillae on the ambulacra are very distinct, the papillae being fairly well expanded. There are about three to four rows of close-set papillae in each ambulacral ray.

Measurements: Length : 48 mm.
 Width at the middle : 9 mm.
 Height at the middle : 8 mm.

Genus *Pentacta* Goldfuss.

(= *Colochirus* Troschel, 1846).

The ventral surface is more or less flattened as a creeping sole bearing three bands of podia, and the dorsal surface is warty or papillate. The thickened ends of the ambulacra form valves for the introvert and also usually for the anus. The tentacles are ten in number, two of them (ventral) smaller than the others. The anterior extremity of the body bears usually five valves. The ambulacral appendages are of two kinds—pedicels and papillae, the latter situated on top of warts a few exceptions, ences. The pedicels which are confined to the ventral surface are, with a few exceptions, placed on the three ambulacra, thus forming distinct longitudinal series. The most anterior and posterior portions of the ventral surface are devoid of pedicels which in these parts are replaced by papillae. Occasionally, papillae may also be found scattered over the ventral interambulacra. The papillae strictly belong to the dorsal surface, where they form rows along the ambulacra alone or are irregularly distributed all over that surface. The calcareous ring is composed of ten simple pieces, devoid of posterior prolongations, the three ventral pieces being often narrower. The deposits consist of larger or smaller reticulate scales, together with one or several kinds of small bodies.

The podia of the belly side are found in two clear rows which are separated from each other. On the back are found only ambulacral papillae. The two median tentacles of the belly side are smaller than the other eight. The anus bears calcaerous teeth. The body wall is greatly thickened by the presence of an abundance of ossicles.

This genus has been more familiarly known as *Colochirus* and is mentioned as such in all earlier literature.

One species, *Pentacta quadrangularis* (= *Colochirus quadrangularis*) collected from Tuticorin, is represented in the Museum collection

Pentacta quadrangularis* (Lesson).*FIGURE 9.**

- Holothuria quadrangularis*, Lesson, Centur. Zoolog., 1830—32, p. 90—91; pl. 31, fig. 1.
- Holothuria quadrangularis*, Jager de Holothur., 1833, p. 22.
- Holothuria quadrangularis*, Brandt., Prodrömus, 1835, p. 53.
- Colochirus quadrangularis*, Selenka, Nachtrag zu den Beiträgen, etc., 1868, p. 112 (part).
- Colochirus quadrangularis*, Semper, Holothurien, Nachträge, 1868, p. 239.
- Colochirus quadrangularis*, Semper, Reisen im Archipel der Philippinen, 1868, p. 60, p. 271.
- Colochirus coerules*, Semper, *ibid.*, p. 59.
- Colochirus quadrangularis*, Théel, "Holothuridea", Part II, Rep. Sci. Res., "H. M. S. Challenger", Zoology, XIV, 1886, p. 120.
- Colochirus quadrangularis*, Pearson, Report on the Holothuriidea, collected by Professor Herdman at Ceylon, Ceylon Pearl Oyster Fisheries Report, Part I, Supplementary Report, V, 1904, p. 196; pl. ii, fig. 21.

This is a widely distributed species and has been recorded from the Philippines, East Africa, Australia, East Indies and Ceylon. The Museum specimen of this species from Tuticorin is perhaps the first record of this species from the Indian Coast.

The body is stumpy and quadrangular. The dorsal ambulacral appendages are very large, placed along the four angles of the body; four to six rows of pedicels are present in each central ambulacrum. The interambulacral spaces are free of papillae and are very smooth. In the three ambulacra of the ventral side are found four to six tube feet along the entire width of the body. The two lateral ambulacra have, excluding these, another row of ambulacral papillae. The papillae of the dorsal side are very high and Semper (*loc. cit.*, p. 59) records that in a specimen 180 to 200 mm. long, the papillae were about 15 mm. long. Ten extraordinarily strongly branched tentacles are present, the two median ventral ones of which being very much smaller.

The colour of the animal in life is reported to be greatly variable, being sometimes dark blue, sometimes red and sometimes green. Very rarely the colour is completely brownish or reddish. The tentacles are speckled with bright red and green. The under side is uniformly bright brownish in colour. The specimens from greater depths are reported to be much darker in colour than those from the shore or shallow waters. In the calcarious ring, the three middle ventral segments are strikingly different from the rest. Pearson (*loc. cit.*, p. 196), records the colour of the specimens in spirit as yellow and dark brown, with a very faint tinge of violet.

The deposits consist of scales, reticulate spheres and cups, and small plates with four larger and some smaller holes, and with spines on one end.

Theél (*loc. cit.*, p. 120), records one specimen 150 mm. long from Hong Kong and describes its colour as being yellowish or greyish white, with some traces of a violet or bluish tone here and there, indicating the true colour of the living animal. The body is quadrangular, with the mouth bent upwards and closed by five ridges or protuberances provided with processes. The anus is dorsal, surrounded by five distinct teeth. A simple or alternating row of rather large, conical processes occurs on each of the four angles, each row or angle having from twelve to sixteen such processes. The processes are said to reach 15 mm. in length in the specimen from Hong Kong recorded by Theél. The pedicels are reported to be five to seven in breadth in each ventral ambulacrum.

Another specimen (recorded by Theél,) 75 mm. long, obtained in the Gulf of Siam, is reported to have a brown colour, and only three to four pedicels in breadth in each series.

A third specimen from Australia recorded by Theel, is reported to be peculiar in that the left dorsal interambulacrum carries three protuberances and the odd interambulacrum one.

Pearson (loc. cit., p. 196) records four specimens from South of Adam's Bridge, Ceylon. Their lengths are recorded as 75 mm., 60 mm., 30 mm. and 40 mm., respectively. These specimens are said to agree well with the typical description of Theel. Pearson records this colour in spirit as yellow and dark brown with a very faint tinge of violet.

Pearson also describes a closely related variety, namely, *Colochirus quadrangularis* var. *mollis* nov., (loc. cit., pl. ii, fig. 21), based on one specimen from south of Theendikodi, Adam's Bridge, $8\frac{1}{2}$ fathoms deep. The length of the specimen is reported to be 100 mm.

This differs from *Colochirus quadrangularis* s. str. in the texture of the body wall. Instead of being very hard, thick and rough, as in *Colochirus quadrangularis* s. str. the skin in the variety *mollis* is soft, thin and comparatively smooth. Although this specimen is larger than any of those of *Colochirus quadrangularis* in the collection examined by Pearson, yet the papillae at the four angles of the body are much smaller comparatively.

The colour of the animal is also reported different from of the Ceylon specimens of *Colochirus quadrangularis*.

The following is the account of the colour of the living animal, as noted by Professor Herdman :—

" Colour of the body a uniform orange slightly mottled with a paler tint. The crown of tentacles are mottled yellow on a dark brown ground. The region between the five valves at the base of the tentacles is white ". Plate ii, figure 21 in Pearson's Monograph is from a drawing in Professor Herdman's notes showing the living animal with the tentacles expanded.

Pearson feels that it is advisable to treat this specimen as a new variety of *Colochirus quadrangularis* with which it agrees in other characters.

Recorded localities.—Bohol (Semper) (?), Africa and Australia (Semper); Sumatra and Macassar (Ludwig); Offack in Waigou Island; Philippines; East Indies and Ceylon. In the Madras Museum collection there is a single specimen of this species from Tuticorin on the East Coast of India, which is thus a new record for this species, extending its range of distribution to the East Coast of India also.

In Ceylon, it has been recorded by Pearson from South of Adam's Bridge.

Specimens in the collection.—A single specimen from Tuticorin, South India, is represented in the Museum collection. The specimen is thick, stumpy and quadrangular and more or less squarish in section. The ventral side is flattened and bears the three ambulacra which are clearly marked each carrying about four to six rows of tube feet (podia) which are all contracted in the present specimen, their presence being indicated only by pits on the surface. The papillae on the dorsal ambulacral appendages are large, thick and stumpy, conical processes and are placed roughly along the four angles of the body. The interambulacral spaces are free of papillae and are smooth. The anterior end of the body is slightly narrower than the hind end and the tentacles are all badly contracted in the present specimen. The specimen is hard and rigid, the integument being thick, leathery and rigid. The colour of the specimen in alcohol is a uniform dull, dirty greyish white.

Measurements :

Length : 65 mm.

Width of the body in the middle : 23 mm.

Height of the body in the middle : 20 mm.

Family PSOLIDAE.

(= Sub-family GASTROPODA of the earlier classification)

The ambulacral appendages are in the shape of pedicels alone, arranged in distinct rows on the flat, discoidal, sole-like ventral surface. The convex dorsal surface is naked, mostly covered with large scales. The tentacles are ten in number, exceptionally fifteen, nearly equal, but the two midventral ones may be reduced in size. The calcareous ring is composed of ten simple pieces not prolonged posteriorly.

The ventral surface is developed as a thin-walled creeping sole with scanty podia along its periphery and in some species also along the mid-ventral radius; whereas the arched dorsal surface is covered with calcareous scales that encroach on the introvert and the anal elevation. The members of this family are often red, orange or pink in colour.

Genus *Psolus* Oken.

This is the main genus of the family Psolidae. In this genus the podia are absent on the dorsal side. In some species there are five valve-like scales that serve to close over the introvert and the anus. The characters of the family Psolidae mentioned above are applicable to the genus *Psolus* as well.

A single species, *Psolus complanatus* Semper, is represented in the Museum collection, by specimens collected from Pamban in the Gulf of Manaar.

Psolus complanatus Semper.

FIGURE 10

Psolus complanatus, Semper "Holothurien" Reisen im Archipel der Philippinen (2) I (Weisbadan), 1868, pp. 61—62 pl. xiii, figs. 19a-b.

Psolus complanatus, Theél, "Holothuridea" Part II, Rep. Sci. Res. "H.M.S. Challenger" Zoology, XIV, 1816, pp. 127-128.

Psolus complanatus, Gravely, "Littoral Fauna of Krusadai Island, in the Gulf of Manaar" Bull. Madras Government Museum (Natural History) New Series, I, No. I, 1927, p. 166.

The body is very flattened and depressed. There are about four to six rows of pedicels arranged in the width of the body along the lateral ambulacra; in the middle one (i.e., the odd series) there are only two or three complete rows. Across the whole width of the body on the dorsal surface, there are about fourteen to sixteen scales or plates, and between the mouth and the anus, ten to twelve larger and several smaller scales are found. These calcareous plates or scales are slightly granulated. The colour of the typical specimens of this species is reported to be uniformly grey.

The calcareous ring is made up of ten pieces which are abruptly truncated at the hind end; the interradials are stout and pointed anteriorly and the radials are longer and deeply cleft in the middle. Through this slit, the water vascular vessels and the nerves enter.

The deposits in the sole consist of rather symmetrical oval buttons with about four holes and rather large knobs round the uneven margin, and with a large central knob. In addition to these, there are smaller, asymmetrical, knobbed, irregularly perforated bodies with the margin uneven and dentate.

Gravely (*loc. cit.*, p. 166), referring to the littoral Holothurians recorded from Pamban, reports that a single specimen of this little Holothurian, mottled dark greyish in colour above, whitish on the sole, and with upwardly directed anterior and posterior

ends, was found at Pamban. This specimen is represented in the Museum collection. It differs from the type specimen described by Semper from the Philippine Islands by its less uniform colour, but agrees closely in the nature of the spicules. The spicules in this specimen (examined by Dr. Gravely) were mostly thick, oval buttons, with four perforations, ten marginal knobs, and a larger central knob on each of the two surfaces. Some of the buttons are reported to be more elongate, with more numerous perforations and knobs.

Dr. Gravely reports that in addition to these, there are also thinner, saucer-shaped perforated plates, with dentate margin, as well as the large plates of the dorsal surface. The saucer-shaped plates of the Pamban specimen are said to differ from the corresponding plates of Semper's specimen in being without knobs and having a more evenly dentate margin.

Recorded localities.—Zamboanga; Pamban, Gulf of Manaar.

Specimens in the collection.—A single small specimen collected from Pamban in 1925 is represented in the Museum collection. It is of a rather mottled dark greyish colour and is somewhat badly contracted. The flattened ventral sole is paler and lighter greyish in colour. The rows of pedicels and the scales across the width of the body on the dorsal surface are clearly seen in the present specimen. The tentacles, ten in number, are fairly well extended.

Measurements: Length: 14 mm.

Width of body at the middle: 6 mm.

Family PHYLLOPHORIDAE.

This is the third and last of the families included under the Order Denodrochirotae, and is distinguished by the more numerous tentacles, usually fifteen to thirty in number, which are of two sizes or of intergrading sizes, more or less arranged in two circlets. The podia may be limited to the ambulacra, or may also extend to the interambulacral areas.

Genus *Phyllophorus* Grube.

This is the main genus of the Family and the members of this genus bear up to twenty tentacles of varying sizes and scattered podia. The tentacles are arranged so as to form two crowns, twelve to sixteen in the exterior and five to six in the interior. The ambulacral appendages are almost without exception in the shape of pedicels, irregularly distributed all over the body. This genus is confined to tropical and sub-tropical waters.

A single species, rather doubtfully identified as *Phyllophorus dubia* (Bedford) is represented in the Museum collection by a single specimen collected from Shingle Island in the Gulf of Manaar.

Phyllophorus dubia (Bedford).

FIGURE. 11.

Orcula (*Phyllophorus*) *dubia*, Bedford, in Willey's Zoological Results 1899, p. 144, pl. xvii, fig. 4.

Orcula tenera, Ludwig, Arb. aus. d. zool. zoot. Inst. in Wurzu., II, 1875, p. 95.

Orcula tenera and *Phyllophorus brocki*, Ludwig, Zool. Jahrb systematik, III, 1888, pp. 812—814; pl. xxx, fig. 20.

Phyllophorus bedoti, Koehler, R., Rev. Suisse de Zool., III, 1895, p. 278, fig. 2.

Phyllophorus brocki, Sluiter, "Holothurien", Siboga-Expeditie, XLIV, 1901, (Livr. I, Lieden, 1904), p. 111.

Phyllophorus sp., Gravely, "Littoral Fauna of Krusadal Island in the Gulf of Manaar", Bull. Madras Government Museum, Natural History, (New Series), I, No. 1, 1927, p. 166.

Bedford (*loc. cit.*, p. 144) has recorded this species from Loyalty Islands (Lifu), but a specimen collected from Shingle Island near Pamban in the Gulf of Manaar and contained in the collection of the Madras Government Museum, referred to by Dr. Gravely (*loc. cit.*, p. 166), appears to be identical with this species.

Bedford (*loc. cit.*, p. 144) states that he has recorded one specimen from Lifu, Loyalty Islands, 10.5 cm. long. Owing to the complete contraction of the tentacles, their arrangement could not be made out properly, but they appeared to be about fifteen in number.

The only deposits that Bedford could find other than the end plates of the tube feet are: (1) Hirselpatchen: these are minute, crenulated nodules like millet seeds similar to those described by Ludwig in *Phyllophorus brocki* (Sluiter, *loc. cit.*, p. 111), and seen in a number of Holothurians, and (2) Occasional, needle-shaped spicules of various sizes pointed at each end and often somewhat curved; both kinds are infrequent, the "Hirseplatchen" occurring loosely aggregated together. The calcareous ring has posterior bifurcate projections made up of a number of pieces on both radialia and interradialia, although only those attached to the former separate to form a definite arch as in *Phyllophorus bedoti* Koehler and *Orcula tenera* Ludwig.

Gravely (*loc. cit.*, p. 166), referring to the single specimen from Shingle Island contained in the Museum collection, reports that it is a little longer and much stouter than the Pamban specimens of *Thyone sacellus* (= *Stolus buccalis*). The deposits consist of rather few needle-shaped spicules, mostly pointed at each end and often slightly curved, and the shape and disposition of these spicules suggest that it may prove allied to or even identical with *Orcula* (*Phyllophorus*) *dubia* which Bedford (*loc. cit.*, 1899, p. 144, pl. xviii, fig. 4) had described from Lifu, Loyalty Islands. The specimen is of a dark purplish brown colour above, paler beneath. The tentacles of the inner ring are much smaller than those of the outer. Referring to the deposits, Dr. Gravely reports that in rare cases one end of a spicule is knobbed (like the head of a pin) or provided with three recurved teeth, but since all the spicules of the latter type examined by him appear to have been broken ones, it was not clear what the other end would have appeared like. These spicules and many others in the specimen examined appeared to have a hollow axis.

Recorded localities: Lifu, Loyalty Islands and Shingle Island, near Pamban, in the Gulf of Manaar.

Specimens in the collection.—A single specimen labelled as "*Phyllophorus* sp." collected from Shingle Island in the Gulf of Manaar, is represented in the Museum collection. The specimen is dark brown in colour, with numerous pedicels scattered irregularly all over the surface of the body. The tentacles are extended fairly well and are disposed in two circles, those in the inner circle being much smaller than those in the outer. The specimen had been dissected longitudinally for studying the disposition of the internal organs. The integument is thick and leathery.

Measurements: Length: 42 mm.
Theel, Width of body at the middle: 16 mm.

ORDER ASPIDOCHIROTA (ACTINOPODA)

In this order, the tentacles are of the peltate type and usually numerous (fifteen to thirty, mostly twenty). Pharyngeal retractors are wanting and the radial longitudinal muscle bands are generally divided in two by a median connective tissue attachment.

along the ambulacrum. The body bears numerous podia, including both locomotory and papillate types. There is a pair of well developed respiratory trees and the large intestine is attached to the right ventral interradius AB. The radial canals supply branches to the tentacles and podia.

Of the three families included in this Order, only two namely, the Holothuriidae and the Stichopodidae are represented in the Museum collection and contain mostly littoral species, while the third family, the Synallactidae, includes typically deep water forms and is not represented in the Museum collection.

Family HOLOTHURIIDAE

The Holothuriidae are mostly large, warty sea cucumbers, common in tropical and subtropical waters, especially in the Indo-Pacific Region. Typically, the ventral side is developed into a creeping sole, bearing locomotory podia with suckers at their tips. The podia are arranged in three bands or are disposed without any definite arrangement, whereas the dorsal surface is warty or papillate. In this family there is but one tuft of gonadial tubules, attached to the left side of the dorsal mesentery. The rete mirabile of the dorsal vessel reaches a high degree of development in this family, forming lacunar tufts along the whole length of the ascending small intestine and involving the left respiratory tree. Cuvierian tubules are present in some species of the family. The tentacular ampullae are very long and slender encircling the aquirpharyngeal bulb.

The principal genus of the family is *Holothuria* and this is represented in the Museum collection by seven species, all of them having been collected from the Pamban area in the Gulf of Manaar.

Genus *Holothuria* Linné.

The tentacles are normally twenty in number, exceptionally more or less than twenty. The ambulacral appendages consist of pedicels alone or papillae alone, or both papillae and pedicels, the former being placed on the dorsal surface and the latter on the ventral. These ventral pedicels are seldom arranged in longitudinal series. A single bundle of genital tubes is present, situated on the left side of the dorsal mesentery. The anus is devoid of calcareous teeth, but sometimes stellate. C-shaped deposits are absent.

Over 100 species of this genus are known to occur. They are mostly elongated forms of dull colouration, varying from white, cream and grey to brown and black.

Seven species of *Holothuria* are represented in the Museum collection, mostly collected from areas around Krasadai Island, Pamban, Rameswaram and neighbouring areas in the Gulf of Mannar and from Tuticorin. They may be distinguished from one another as follows. The colours mentioned in the key denote the colours of the living animals or of freshly preserved specimens:—

1. Colour of the specimens dark purplish brown, almost black; specimens attaining a large size, often a foot or even more in length *H. atra*.
—Colour of the specimens not blackish or dark purplish brown, often much lighter and paler and sometimes variegated with transverse bands
2. Specimens large and often very bulky and thick, being sometimes nearly a foot in length and almost three or four inches in diameter; colour of the specimens varying from greyish or greenish grey to almost black and variegated with numerous transverse paler or yellow streaks *H. scabra*.
—Specimens much smaller and more slenderly built; colour and pattern of colouration not as above; often paler and more brownish and not conspicuously variegated with transverse streaks 3

3. Colour in life auburn on the dorsal surface with some large spots or bands of yellowish white colour and yellowish white on the ventral surface; colour in spirit dark brown with a violet tinge on the ventral surface, and lighter on the dorsal surface. Ambulacral appendages in the form of cylindrical pedicels scattered all over the body *H. marmorata*.
—Colour not as above, usually darker on the dorsal side and paler on the ventral side; as a rule more brownish, either dark brownish or pale brown, greyish or maroon 4
4. Colour of the living specimens usually dark brownish, or sometimes reddish brown, or reddish chestnut, with the ventral surface paler and more light-coloured than the dorsal surface. Ventral pedicels more numerous than the dorsal papillae 5
—Colour of the living specimens not as above, either pale brown or light grey, with somewhat indistinct white spots, or varying from greyish white to maroon
5. Dorsal processes in the form of wart-like pedicels. Spicules are characteristically in the form of roughened, rod-shaped or spindle-shaped bodies somewhat resembling those of *Alcyonaria* *H. lubrica*.
—Body more or less markedly cylindrical and tapering equally towards each extremity. Mouth surrounded by a crown of papillae. Spicules in the form of buttons without processes and mostly with three pairs of perforations and small tables similar to those of *H. atra*. Specimens of a dark brownish colour, but of a more yellowish tint than that of *H. lubrica*. *H. monacaria*.
6. Dorsal ambulacral appendages of two kinds, namely, papillae, with a conical form devoid of sucking discs, and pedicels which are cylindrical, and provided with small sucking discs. Colour varying from greyish white or pale brown to maroon or dark brown, the pedicels having a more reddish colour than the general ground colour *H. vagabunda*.
—Body somewhat small and slender; specimens of this species usually live in cavities in dead coral; dorsal ambulacral appendages not differentiated as above, Colour pale brown or light greyish brown with somewhat indistinct white spots especially along each dorsal ambulacrum *H. pardalis*.

Holothuria atra Jager.

FIGURE 12.

- Holothuria* (Subgenus *Microthele*) *affinis*, Brandt, 1835.
Holothuria atra. Solonka, Z. f. w. z., 17, 1867, p. 327, pl. xviii, figs. 52 and 53.
Holothuria atra, Sæmper, Reisen im Archipel der Philipinen, 2, Th., 1 Band, 1838, pp. 88 and 250; pl. xxvi.
Holothuria atra, Türel, Challenger Reports, Holothuridea, 1886, pp. 181 and 213—214; pl. vii fig. 4.
Holothuria atra. Köhler, R., Catalogue raisonné des Echinodermes recueillies par M. Korotne vauz îles de la Sonde, Mem. Soc. Zool. France, 1895, p. 382.
Holothuria atra, Whitelegge, The Echinoderms of Funa-futi Mem. Austral. Mus. III, 1899, p. 161.

- Holothuria atra*, Lampert, Die von Dr. Stuhlmann in der Jahren 1888 and 1889 an der Ostküste, Africas gesammelten Holothuriens Mitt. Mus., Hamburg, XIII, 1896, p. 56.
- Holothuria atra*, Bedford, Report on the Holothurians collected by M. J. Stanley Gardiner at Funafuti and Rotuma, Proc. Zool. Soc. London, 1898, p. 839.
- Holothuria atra*, Ludwig, Echinodermen des Sansibargebietes (Abh. Senckenberg. Ges. XXI, 1899, p. 559.
- Holothuria atra*, Bedford, Holothurians, Willey's Zoological Results, Part II, 1899, p. 147.
- Holothuria atra*, Clark, Synopses of North American Invertebrates, XV, The Holothuroidea, American Natural., XXXV, 1901, pp. 485 and 495.
- Holothuria atra*, Sluiter, "Holothurien", Siboga-Expedition, XLIV, 1901, (Livr. I, Leiden 1904), p. 8.
- Holothuria atra*, Clark, Echinodermata: Papers from the Hopkin Stanford Galapagos Expedition, 1898—1899, XII, Proc. Washington Acad., IV, 1902, p. 530.
- Holothuria atra*, Voeltzkow, Die von Aldabra bis. Jetzt bekannte Flora and Fauna, Abh. Senckenberg. Ges., XXVI, 1902, p. 565.
- Holothuria atra*, Whitelegge, The Crustacea and Echinoderma in: Note on the Zoology of Paonopa or Ocean Island and Nauru or Pleasant Island Gilbert Group, Rec. Austral. Mus., V, 1903, p. 13.
- Holothuria atra*, Pearson, Report on the Holothurioida collected by Professor Herdman at Ceylon, Ceylon Pearl Oyster Fisheries Report, Part I, Supplementary Report, V, 1904, pp. 202—2.
- Holothuria atra*, Koehler and Vanay, "Holothuries recueillies par l'investigateur dans l'Océan Indien", Calcutta, II, 1, p. 5.
- Holothuria atra*, Gravely, Littoral Fauna of Krusadai Island, Bull. Madras Government Museum, I, No. 1, 1927, p. 164.

This is a common and widely distributed littoral species of Holothurian and is extremely well represented in the Indo-Pacific Region. Around Krusadai Island in the Gulf of Mannar, it is very common in the lagoon on the South side of Krusadai Island. Living specimens of this species are generally found in fairly large numbers on the surface of the sandy ground in shallow water. They are dark purplish brown or almost blackish during life and attain a length of over twelve inches.

Theél, (*loc. cit.*, pp. 213—214) records this species from Amboina and Fiji Islands in his "Challenger" Reports. The specimens collected at these localities are reported to be about 180 mm. When fully extended, they must have been much larger. The dorsal papillae are much more scattered than the ventral pedicels and do not exceed them in size.

Pearson (*loc. cit.* p. 202) reports seven specimens of this species, most of them being very much contracted. The specimens examined by him were found at various localities around Ceylon—in the Gulf of Mannar, at Trincomalee and at Galle, and also at Pearl Banks off Aripu. Pearson reports that the colour of the specimens of this species in alcohol is dark brown on the dorsal surface and lighter on the ventral; Professor Herdman's notes mention that at least some of the specimens when alive were quite black above, but of a pink colour below. But those represented in the Madras Museum collection, collected from Krusadai Island in the Gulf of Mannar appear to be almost uniformly blackish or very dark purplish brown. The dorsal papillae are smaller than the ventral

pedicels. Pearson reports that since Cuvierian organs were absent in all the specimens examined by him, it is quite probable that this species does not possess Cuvierian organs. Pearson also reports the presence of twenty tentacular ampullae in each of his specimens. The left respiratory tree in this species is much larger than the right, the former extending to the extreme anterior end of the body.

Semper (*loc. cit.*, p. 88) reports that in the localities from which his specimens of this species were collected, (Philippines, Samoa Islands, etc.), they were found living together gregariously in the sandy areas of the coral reefs and were so completely covered with sand particles that it was difficult to detect their presence in their sandy environment. Many specimens collected from the Krusadai Island area in the Gulf of M^aar were also found similarly coated with sand particles though to a much less extent.

The deposits consist of small, incomplete buttons, and small tables with a small perforation in the smooth-edged disc at the base of each rod of the spire; this perforation may sometimes be absent. The rods are joined by one tire of cross pieces below the terminal ring, and each bearing at the apex one vertical and two outwardly directed teeth.

Theél, *loc. cit.*, pp. 213-214) reporting on the Challenger specimens, records that the small discs of the tables are either smooth on the margin or provided with spines, and that fenestrated, often symmetrically bilateral plates are to be found close to the well developed terminal plate of the pedicels. The papillae contain slightly curved, smooth or spinuous rods, mostly with the enlarged ends fenestrated or branched. The terminal plates of the dorsal papillae are very rudimentary.

Pearson (*loc. cit.*, p. 202), referring to the specimens from Ceylon, reports that the discs of the tables are smooth and have no peripheral perforations.

Recorded localities : This is a widely distributed species in the Indo-Pacific Region and has been recorded from various around Ceylon and in the Gulf of Mannar, at Tirunomalee and at Galle. In Ceylon, it has also been recorded from the Pearl Banks, off Aripu. Besides, this species has been recorded from Amboina, Fiji Islands, Philippines, Samac Islands, Viti Islands, Andaman Islands, Flat Island, Coast of Arrakan and from Krusadai Island near Pamban in the Gulf of Mannar.

Specimens in the collection :

Reference Collection :

(1) One specimen : Locality : Rameswaram. The specimen was black in life, but the preserved specimen in alcohol is bleached dirty pale brown and transversely wrinkled. The tentacles are retracted.

Measurements : Length of the body : 175 mm.

Width of the body at the middle : 56 mm.

(2) Three fairly large specimens collected in 1925. Locality : Krusadai Island.

The specimens are dark brownish in colour. In one of them, the tentacles are fairly well extended, but in the other two they are somewhat contracted. The ventral pedicels are much more numerous and crowded and closely set and larger than the dorsal papillae which are fewer and more widely scattered. The three specimens are almost of the same size.

Measurements (of the largest specimen) :

Length of the body : 300 mm. (1 foot).

Width of the body at the middle : 58 mm.

(3) One specimen, collected in September, 1943. Locality : Krusadai Island, Gulf of Mannar.

The specimen is dark brown, with a slightly purplish tinge. The tentacles are almost completely retracted. The numerous closely crowded ventral pedicels are well seen.

Measurements: Length of the body: 170 mm.

Width of the body at the middle: 52 mm.

Gallery Collection:

(4) One specimen: Locality: Krusadai Island, Gulf of Manaar.

The specimen is almost completely bleached and faded into a uniform dirty white colour. The branched tentacles, however, are well extended and clearly seen. The numerous, closely crowded ventral pedicels are finely expanded and seen as small, cylindrical, finger-like processes.

Measurements: Length of the body: 210 mm.

Width of the body at the middle: 43 mm.

Holothuria lubrica Selenka.

FIGURE. 13.

Holothuria lubrica, Selenka, Beitrage, 1867, p. 329.

Holothuria lubrica, Lambert, Die Seewalzen, 1885, p. 90.

Holothuria lubrica, Theel, "Holothuridea" Par. II, Rep. Sci. Res., "H.M.S. Challenger" Zoology, XIV, 1886, p. 205.

Holothuria lubrica, Ludwig, Die von G. Chierchia gesammelten Holothurien, Zool. Jahrb. Bd. 1887, p. 4.

Holothuria lubrica, Lambert, Die von Dr. Stuhlmann in den Jahren 1888 und 1889 an der Ostküste Africas gesammelten Holothurien (Mitt. Mus. Hamburg), XIII, 1896, p. 58.

Holothuria lubrica, Ludwig, Die Holothurien der Sammlung Plate (Zool. Jahrb., supp. 4, Fauna Chilensis Heft II, 1898, p. 434).

Holothuria lubrica, Ludwig, Echinodermen des Sansibargebietes (Abh. Senckenberg Ges., XXI, 1899, p. 560.

Holothuria lubrica, Sluiter, "Holothurien", Siboga Expeditie, XLIV, 1901, (Livr. I, Leiden, 1904), p. 8.

Holothuria lubrica, Koehler and Vancy, "Holothuries recueillies par l' Investigator dans l'Océan Indien", Calcutta, II, 1908, p. 10, pl. I, fig. 5 a and b.

Holothuria lubrica, Gravely, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bull. Madras Government Mus., I. No. I, 1927, p. 163.

This is a widely distributed species and has been recorded from various localities in the Indian and Pacific Oceans and in the West Indies.

Dr. Gravely (*loc. cit.*, p. 163) has recorded a single specimen of this species from Shingle Island, in the Gulf of Manaar, about 12 cm. long, dark brownish in colour. This specimen, together with another, specimen collected from Shingle Island in 1925 and two other specimens, one from Krusadai Island and another from Pulli Reef, Krusadai Island, in the Gulf of Manaar, collected in September, 1944, are now contained in the Museum collection.

This species may be readily distinguished from the remaining species of *Holothuria* in the Museum collection by its roughened, rod-shaped or spindle-shaped spicules, somewhat resembling those of *Alcyonaria*.

Theel (*loc. cit.*, p. 205), reports that the colour of this species (when alive) is dark brown, lighter on the ventral surface. The inner surface of the peristome bears blackish spots. The anus is fringed with small, elongate papillae. The ventral pedicels are much

more crowded than the dorsal and a line of demarcation may be made out at the transition between the two zones. A narrow, naked space is often to be seen along the odd ambulacrum, separating the ventral pedicels into two longitudinal series. The dorsal processes may be regarded either as papillae or pedicels. Like the ventral ones they have a distinct, though smaller, sucking disk, and a well developed terminal plate. There is considerable variation in the shape of these pedicels. In some specimens, they are more obviously cylindrical than in the others and sometimes in the very same specimen, some are cylindrical while others are more elongately conical with smaller sucking disk. The dorsal sucking discs are dark, while the larger, ventral ones are pale. The calcareous rods have a more or less rough surface, are often not very distinctly curved, and have the ends slightly spinuous. In the larger specimens, Cuverian organs are reported to be present.

The most characteristic features of this species are that the ventral pedicels are more numerous than the dorsal "wart-like" pedicels. The deposits (as reported by Theel in his "Challenger" specimens, are spinuous, curved rods.

Koehler and Vaney (*loc. cit.*, p. 10) report several specimens of this species ranging in length from 95 mm. to 115 mm.; their colour is reported, when alive, to be a reddish maroon or reddish, chestnut; with the ventral surface paler or lighter coloured than the dorsal surface. The appendages are said to have brownish extremities and their arrangement is similar to that found in *Holothuria parva*.

The integument contains calcareous rods which are very characteristic. They present on their surface a series of minute granulations which are visible only under a magnification of about 200 times. Towards the sides, the rods are very strongly fringed and they are also thicker and provided with an incomplete series of lateral openings.

The calcareous ring in this species is said to be identical with that of *Holothuria glaberrima*.

Selenka reports the presence of two or three madreporic canals (stone canals) while Ludwig and Semper have indicated only one. The specimens examined by Koehler and Vaney contained two bundles of three to five madreporic tubes placed to the right and to the left of the dorsal mesentery.

As the specimens examined by Koehler and Vaney are reported to have been partly eviscerate, they had not been able to comment on the presence or absence of the Cuverian Organs. Ludwig notes a bundle of small tubes of the Cuverian organ, although according to Selenka, the Cuverian organs are said to be lacking in this species.

In the specimens examined by Koehler and Vaney, the genital organs are said to consist of number of yellowish, branched tubules 40 to 50 mm. in length.

Recorded localities.—This species has been recorded from various widely separated localities in the Indian and Pacific Oceans and in the West Indies. Theel (*loc. cit.*, p. 205) records it from the Acapulco, Sanghir and Mazatlan (in his Challenger Reports). Koehler and Vaney (*loc. cit.*, p. 10) have specifically recorded this species from the Andaman Islands and from the Galle Coast in Ceylon. Dr. F.H. Gravelly (*loc. cit.*, p. 163) has recorded it from Shingle Island, near Krusadai Island, in the Gulf of Manaar, and later specimens of this species have been collected from the Pulli Reef on Krusadai Island in the Gulf of Manaar.

Specimens in the Collection.—(1) One specimen. Locality: Shingle Island. The colour of the specimen is brownish, somewhat darker brown on the dorsal side and paler on the ventral. The pedicels are seen well developed and are wart-like and many of them are definitely cylindrical with a dark brown sucking disc at their tips. The ventral pedicels are much more crowded than the dorsal ones. The integument is soft and quite flexible. The crown of tentacles round the mouth is fairly well extended.

Measurements: Length of the body: 62 mm.

Width of the body at the middle: 22 mm.

As the specimen has probably eviscerated, the body is flattened and flabby.

(2) One specimen, collected at Shingle Island, in 1925. The colour is rather dark brownish. The pedicels are well developed, though contracted, and are much more crowded and numerous on the ventral side where they form three more or less well defined longitudinal bands. The tentacles are contracted. The specimen has been slit open by a median longitudinal incision and the contents partly removed so that the integument forms a flattened, leathery bag.

Measurements: Length of the body: 100 mm.

Width of the body at the middle: 38 mm.

(3) A rather plump, wrinkled, somewhat pale brown specimen from Pulli Reef, Krusadai Island, in the Gulf of Manaar, collected in September, 1944. It is somewhat darker brown on the dorsal side. The pedicels on the ventral side are somewhat longish, cylindrical and closely crowded.

Measurements: Length of the body: 95 mm.

Width of the body at the middle: 33 mm.

(4) A fairly large, well preserved specimen with the tentacles well expanded, dark brown on the dorsal side, and pale creamy brown on the ventral side. The line of demarcation between the darker and lighter zones is clearly seen and well defined. The pedicels are well extended.

Measurements: Length of the body: 120 mm.

Width of the body at the middle: 40 mm.

Holothuria monacaria (Lesson).

FIGURE 14.

Psolus monacaria, Lesson, Centurie Zoologique, 1830, p. 225.

Holothuria monacaria, Semper, Reisen im Archipel der Philippinen, 2, Th., 1 Band, 1868, pp. 78 and 247.

Holothuria monacaria, Lambert, Die Seewalzen, 1885, p. 72.

Holothuria monacaria, Theél, "Holothuridea", Part II, Rep. Sci. Res., "H. M. S. Challenger", Zoology, XIV, 1886, pp. 172—173 and 217 to 218, pl. viii, figs. 10 a to f.

Holothuria monacaria, Koehler, Echinodermes de la baie Amboine, Rev. Suisse Zool., t. III, 1895, p. 281.

Holothuria monacaria, Koehler, Echinodermes des îles de la Sonde, Mem. Soc. Zool. France, 1895, p. 381.

Holothuria monacaria, Lambert, Die von Dr. Stuhlmann inden Jahren 1888 and 1889 an der Ostküste Africas gesammelten Holothurien, Mitt. Mus. Hamburg, XIII, 1896, p. 54.

Holothuria monacaria, Bedford, on the Holothurians collected by M.J. Stanley Gardiner at Funafuti and Rotuma, Proc. Zool. Soc. London 1898, p. 841.

Holothuria monacaria, Bedford, "Holothurians" A. Willey's Zoological Results, Part II, Cambridge, 1899, p. 146.

- Holothuria monocaria*, Ludwig, *Monothurien des Sansibargebietes*. Abh. Senckenberg, Ges., XXI, 1899, p. 557.
- Holothuria monocaria*, Sluiter, "Holothurien" Siboga-Expeditie, XLIV, 1901, (Livr. I, Leiden, 1904), p. 11.
- Holothuria monocaria*, Pearson, Report on the Holothurioidea collected by Professor Herdman at Ceylon, Ceylon Pearl Oyster Fisheries Report, Part I, Supplementary Report, V, 1903, p. 201.
- Holothuria monocaria*, Koehler and Vaney "Holothuries recueillies par l'Investigateur dans 'l'Océan Indien'", Calcutta, II, 1908, p. 11.
- Holothuria monocaria*, Gravely, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bulla Madras Government Museum, Natural History, (New Series), I, No. 1, 1927, p. 164.

This species is reported by Semper (*loc. cit.*, p. 78) to be a common and widely distributed species, ranging from Zanzibar to Australia and the Sandwich Islands. The specimens collected from the Krusadai Island area in the Gulf of Manaar (and represented in the Museum collection) were found among stones. Dr. Gravely (*loc. cit.*, p. 164), reports four specimens of this species about 15 cm. long, as having been collected from the Krusadai Island area in the Gulf of Manaar, three from Shingle Island and one from Krusadai Island.

Dr. Gravely (*loc. cit.*, p. 164) records that the specimens are of a dark brownish colour, but are of a somewhat more yellowish tint than those of *Holothuria lubrica*. In the specimens of *Holothuria monocaria* from Krusadai Island reported by Dr. Gravely, the tubercles on the dorsal surface are described as being pale yellowish, contrasting strongly with the ground colour, and the podia (tube feet) on the ventral surface are arranged in three very distinct rows. In the other specimens these characters are not very clear.

Theel, in his "Challenger" Reports (*loc. cit.*, p. 172) has recorded two specimens of this species from Fiji Island and one from Ternate, Molucca Islands.

The body is more or less markedly cylindrical, tapering equally towards each extremity. The length of the largest specimen recorded by Theel is about 100 mm. The tentacles are twenty in number and generally retracted within the body in preserved specimens. The mouth is surrounded by a crown of small papillae. The anus also carries some small, more irregularly disposed papillae. The ventral pedicels seem to be more numerous than the dorsal papillae. Both kinds of ambulacral appendages seem to reach about the same size, though the papillae are broader at the base. When fully extended, they attain a length of about 4 mm. or slightly more. In view of the fact that the papillae in preserved specimens are mostly completely retracted, it is not easy to distinguish their conical form the cylindrical one which characterizes the pedicels. The sucking discs of the papillae are minute in comparison with those of the pedicels and there is also a great difference in size between the respective terminal plates. Owing to the contracted and wrinkled state of the specimens examined by Theel, he reports that the arrangement of the pedicels in three longitudinal series is not very clear in his specimens. The dorsal papillae are also not said to present any distinct arrangement in longitudinal rows, in his specimens, probably for the same reason.

Theel describes the colour of the specimens of this species in alcohol as follows: The ventral surface is of a light yellowish grey colour. The dorsal surface is darkish brown, tending to be more or less greenish, excepting the papillae and a space round their base, which are yellowish white. In wrinkled and contracted specimens, the dorsal surface gives the impression of being transversely streaked with brown and yellowish white.

The calcareous ring is of the usual shape, without posterior prolongations. Two ventral Polian vesicles are present. A single, dorsal, madreporic canal is present. Theel reports that the genital organs have been destroyed in the "Challenger" specimens examined by him.

Dr. Gravely (*loc. cit.*, p. 164) reports that the spicules are similar in all the specimens of this species from the Pamban area, examined by him. The buttons are described as being without processes and as having mostly three pairs of perforations. The tables are reported to be small and of the same general form as those of *Holothuria atra*, but are said to have a larger number of perforations in the disc, without vertical teeth on the terminal ring of the spire and to have the eight outwardly directed teeth equally spaced.

Theél (*loc. cit.*, p. 172) referring to the specimens examined by him in the "Challenger" collection, reports that the deposits in this species bear the closest resemblance to those of *Holothuria pardalis* Selenka, but that the tables are devoid of spines on the disks, and the buttons are more uniformly crowded beneath the former all over the body. The numerous tables in the specimens examined by him are reported to have the disc small and smooth, and the spire composed of four rods united by a single transverse beam. The spire terminates in about eight or more teeth. The tables are said to measure about 0.048 mm. in height and their discs up to 0.056 mm. in diameter.

The buttons are usually pierced by six holes, and vary slightly in size, but the larger ones have a length of 0.068 mm. In the pedicels and papillae the buttons are reported to grow often slightly larger, and are sometimes pierced by more than six holes. The pedicels bear near their ends irregularly rounded, perforated end plates, or even more elongate, rod-like ones which are of a more or less marked bilateral shape. Besides larger, spinous or perforated, irregular rods resembling those in the pedicels, the papillae carry small, more or less curved, simple or branched, spinous rods. The small, supporting rods of the papillae are described by Theél as measuring only 0.05 mm. in length, while the larger ones noted by him are said to reach 0.2 mm. in length.

Pearson (*loc. cit.*, p. 201) records, in his Ceylon Pearl Oyster Reports, one specimen of this species from Aripu Reef, and another specimen from the northern part of the Gulf of Mannar at a depth of four to forty fathoms. The lengths of the specimens are cited by him as 75 mm. and 38 mm. respectively.

The colour of the preserved specimens in alcohol is described by Pearson as brown, with yellow rings around the papillae. The pedicels are described as light brown and the tentacles yellow. Referring to his Ceylon specimens of this species, Pearson records that in this species, the dorsal surface bears papillae and the ventral surface pedicels. Over the anterior one-third of the length of the body, the papillae are described as being arranged in five distinct longitudinal rows. In the posterior two-thirds, they are more irregular. The pedicels are also arranged in five more or less irregular rows on the anterior third of the ventral surface and they are more irregularly scattered over the remaining two-thirds of the length of the body. The deposits in Pearson's Ceylon specimens are said to agree with those figured by Theél in his "Challenger" Reports. Pearson states that although the Ceylon specimens differ in the arrangement of the pedicels and papillae from Theél's description of *Holothuria monacaria*, these characters appear to be only minor local variations and there seems to be no doubt as to their identity with this species.

Bedford (*loc. cit.*, 1899, p. 146) records three specimens of this species from Lifu, Loyalty Islands, measuring 4.5 cm., 10 cm., and 12 cm. in length. In the smallest of these specimens, a few of the discs of the tables are described as bearing short spines. The only specimen in this batch, dissected, contained one Polian vesicle and one Stone canal, free for about one-third of its length; in the two larger specimens, the anterior end of the body is much thinner and more transparent than the rest of the body, but Bedford doubts that this is a specific character and feels that it might be due to the method of killing.

Recorded localities.—Semper (*loc. cit.*, page 78) states that this is a common and widely distributed species, ranging in its distribution from Zanzibar to Australia and the Sandwich Islands. Its distribution ranges generally over the Indian Ocean, East Indies, Australia and the Pacific Islands. Pearson (*loc. cit.*, page 201) records one specimen from Aripu Reef and one specimen from the northern part of the Gulf of Mannar. Bedford (*loc. cit.*, 1899, page 146) has recorded this species from Lifu,

Loyalty Islands and Koehler and Vaney (*loc. cit.*, page 11) from the Laccadive Islands, Kabusa Island in the Mergui Archipelago, the Andaman Island and the Persian Gulf. In the Madras Museum collection, specimens from Krusadai Island and Shingle Island in the Gulf of Mannar, are represented.

Specimens in the collection.—There are four specimens of this species in the reference collection and one specimen exhibited in the Gallery.

I. Reference Collection:

(i) Two specimens—Locality: Shingle Island, 125.—Both specimens are dark brownish, hard and rigid, with a tough, leathery integument which is somewhat coarsely wrinkled and folded. The specimens are in a rather wrinkled and contracted state and both of them have eviscerated, the Cuverian organs and respiratory trees having been rejected out of the specimens. The papillae and pedicels appear more or less similar owing to their contracted state, but the ventral pedicels are seen to be more numerous and closely crowded than the dorsal ones. One of the specimens is longer and thinner, while the other is comparatively shorter and thicker

Measurements: (a) of the longer specimen:

Length of the body: 241 mm.

Width of the body at the middle: 21 mm.

(b) of the shorter and thicker specimen:

Length of the body: 144 mm.

Width of the body at the middle: 32 mm.

The voided out contents (present in the container) contains the dirty greyish white thread-like tubes of the Cuverian organs.

(ii) One small specimen (probably a young specimen): Locality: Krusadai Island, 1925.

The specimen is moderately dark brown (but lighter brown than the preceding specimens), with rounded, scattered, white spots all over the body. The specimen is rather hard and rigid and has eviscerated. The pedicels and papillae are short and badly contracted. The tentacles are also contracted and are dirty greyish white in colour.

Measurements: Length of the body: 165 mm.

Width of the body at the middle: 21 mm.

(iii) One specimen, fairly thick, but rather contracted, posteriorly and inflated anteriorly. Locality: Shingle Island, September, 1948.

The specimen is pale whitish brown, unlike the preceding specimens and there is no trace of distinct white spots. The specimen is intact, and has not eviscerated. The papillae are small creamy yellowish white, contracted and densely crowded on the ventral side, sparse and scattered on the dorsal side which is transversely wrinkled owing to the contraction of the specimen. The crown of tentacles is dark brownish; they are badly contracted.

Measurements: Length of the body: 146 mm.

Width of the body at the middle: 41 mm.

II. Gallery Collection:

(iv) One specimen: Locality: Krusadai Island, in the Gulf of Mannar, This specimen is faded dirty greyish white and has the tentacles well expanded. The pedicels and papillae are well extended, and are more numerous and closely crowded than on the dorsal side.

Measurements : Length of the body : 174 mm.

Width of the body at the middle : 35 mm.

***Holothuria pardalis* Selenka.**

Figure 15.

- Holothuria pardalis*, Selenka, Beitrage zur Anatomieu. Systematik der Holothurien, 1867, p. 336.
- Holothuria pardalis*, Koehler, Echinodermes de la baie d' Amboine Rev. Suisse Zool., t. III, 1895, p. 283.
- Holothuria pardalis*, Koehler, Echinodermes desiles de la Sonde (Mem. Soc. Zool. France, 1895, p. 384).
- Holothuria pardalis*, Whittlelegge, The Echinodermata Funafuti, (Mem. Austral. Museum, III, 1896, p. 161).
- Holothuria pardalis*, Lampert, Die von Dr. Stuhlmann in den Jahren, 1888 dan 1889, an der Ostkuste Afrikas gesammelten Holothurien, Mitt. Mus. Hamburg, XIII, 1896, p. 52.
- Holothuria pardalis* Bedford, Report on the Holothurians collected by M.J. Stanley, Gardiner at Funafuti and Rotuma (Proc. Zool. Soc. London, 1898, p. 839).
- Holothuria pardalis*, Ludwig, Echinodermen des Sansibargebietes (Abh. Senck. Ges., XXI, 1899, p. 559.).
- Holothuria pardalis*, Bedford, "Holothurians", A. Willey's Zoological Results, Part II, 1899, p. 145.
- Holothuria pardalis*, Sluiter, Die Holothurian der Siboga Expeditie, 1901, p. 12.
- Holothuria pardalis*, Voeltzkov, Die von Aldabra bis jetzt bekannte Flora and Fauna (Abh. Senck. Ges., XXIV, 1902, p. 565).
- Holothuria pardalis*, Perrier, R., Holothuries antarctiques du Museum d' Historire Naturelle de Paris, Ann. Sei. Nat., (9), I, 1904, p. 15.
- Holothuria pardalis*, Vaney, Holothuries recueilles par M. Ch. Gravier sur la Cote francaise des Somalis, Bull. Mus. Paris, 1905, p. 189.
- Holothuria pardalis*, Theél, "Holothuridea", II, Rep. Sci. Res. "H.M.S. Challenger", Zool., XIV, 1886, pp. 224-225.
- Holothuria pardalis*, Koehler and Vaney, "Holothuries recueilles par l' Investigator dans l'Océan Indien", Calcutta, II, 1908, p. 13.
- Holothuria pardalis*, Gravely, "Littoral Fauna of Kru sadai Island, in the Gulf of Manaar", Bull. Madras Government Mesuem, Natural History, 1, No. 1, 1927, p. 164.

This is a widely distributed species in the Indo-Pacific Region. Specimens of this species usually live in cavities in dead coral. This is the smallest and most slender of the species of *Holothuria* found in the Kru sadai Island area, although it attains a length of nearly 15 cms. It is of a pale brown colour, with somewhat indistinct white spots.

The specimens of this species collected by Bedford (*loc. cit.*, p. 145) from New Caledonia have been referred to by him as belonging to the variety *insignis* Ludwig, of the species *Holothuria pardalis*. The specimens are reported to be light grey in colour with violet brown spots.

Theél (*loc. cit.*, pp. 224-225); referring to the Challenger specimens of this 110 mm. and the colour in alcohol of this specimen is reported to be dirty brown.

Koehler and Vaney (*loc. cit.*, p. 13) report that the specimens examined by them from Andamans, Mergui and other localities show some variations in colouration and the pedicels are sometimes regularly arranged.

Dr. Gravely (*loc. cit.*, p. 164) describes the deposits, as examined by him in the specimens from the Gulf of Mannar as follows: the buttons are somewhat irregular **some smooth, some knobbed and some incomplete**. The tables are also irregular with the terminal ring of the spire often incomplete, with teeth varying in number accordingly; or the spire may be still further reduced or absent, leaving only the disc with its four perforations and spinous margin; occasionally the spines on the margin of these simple discs are also obsolete.

Theél (*loc. cit.*, pp. 224-225) has recorded specimens of this species as long as species reported by him, records that some specimens are light greyish brown in colour, with a row of about ten dark spots along each dorsal ambulacrum. The dorsal ambulacral appendages are said to have a slightly conical form. Sometimes the circles of irregular buttons give the surface of the skin a granulated aspect. The small, scattered, dorsal appendages resemble, papillae.

The deposits, are observed in the Challenger specimens of this species are described by Theél as follows:—

The tables have often their spinous discs small and annular and the spire slightly reduced. The buttons, collected in groups or circles, are often very asymmetrical, generally pierced with six or more holes. Sometimes only one side of them is developed, and they usually bear some indistinct elevations. The dorsal appendages are supported by slightly curved, almost smooth rods, with the ends slightly enlarged and perforated, and the terminal plates are small. The ventral pedicels have a large, **terminal end plate and bilaterally symmetrical, perforated, rod-like plates**.

Recorded localities.—This is a widely distributed species and has been recorded from Mergui, Arakan, Andaman Islands, Cheduba Islands, besides the Gulf of Mannar. Its distribution ranges from Zanzibar to New Caledonia and the Sandwich Islands. Theén (*loc. cit.*, pp. 224-225) records this species from Sandwich Islands, Zanzibar (Selenka), Navigator Islands and Port Mackay (Semper); Mozambique (Semper); Red Sea (Semper, Ludwig), Nang kauri (Ludwig); Glorioso Islands (Bell). In the Gulf of Mannar, this species has been collected from Krusadai Island, Pulli Reef and Shingle Island, and many specimens from these localities are represented in the Museum collection.

Specimens in the collection.—Several wet-preserved specimens from Shingle Island and Krusadai Island in the Gulf of Mannar are represented in the Museum collection, one in the Gallery exhibited collection and the rest in the reference collection.

I. Reference Collection :

(1) Five fairly large specimens and two rather small ones. Locality: Shingle Island, Gulf of Mannar, collected in 1924.

The specimens are all of a pale dirty greyish brown colour, with scattered, indistinct white spots and blotches. The papillae are in the form of pale, translucent, white, cylindrical, short processes. In addition to these, there are numerous, closely crowded, wart-like pedicels all over the surface. The specimens are fairly well preserved and in some of them the tentacles are fairly well expanded.

Measurements (of the longest specimen among the five large specimens) :

Length of the body : 138 mm.

Width of the body at the middle : 16 mm.

The other four specimens in this lot are nearly of the same size, or only very slightly smaller.

Measurements (of the larger of the two small specimens):

Length of the body: 88 mm.

Width of the body at the middle: 14 mm.

(2) Eight rather poorly preserved, small and shrunken specimens. Locality: Shingle Island, Gulf of Manaar, collected in 1925.

The specimens in this lot are all badly distorted, rigid and pale earthy brown in colour. The tentacles are contracted, but the papillae are well seen at least in the larger specimens.

Measurements (of the largest specimen):

Length of the body: 113 mm.

Width of the body at the middle: 18 mm.

Measurements (of the smaller, but thicker and more robust specimen):

Length of the body: 81 mm.

Width of the body at the middle: 18 mm.

The other specimens in this lot are all thinner and shorter.

(3) Three specimens: Locality: Krusadai Island, Gulf of Manaar, collected in 1924.

These specimens are pale, dirty, whitish grey-brown, and are well preserved, with the tentacles and papillae well expanded.

Measurements (of the largest specimen):

Length of the body: 88 mm.

Width of the body at the middle: 14 mm.

(4) Besides the above specimens, there are also numerous other moderate to small-sized specimens of *Holothuria pardalis* from Krusadai Island in the Gulf of Manaar, collected in September, 1944, contained in the Reference Collection. These are all pale creamy brown or brownish white in colour, and the tentacles and papillae are well expanded and clearly seen in some of these specimens. Most of the specimens are strongly transversely wrinkled.

Measurements (of an average specimen in this lot):

Length of the body: 100 mm.

Width of the body at the middle: 18 mm.

II. Gallery Collection:

(5) One specimen. Locality: Shingle Island, Gulf of Manaar. This is the largest and most well preserved specimen of this species in the Museum collection, and the tentacles and papillae are well expanded.

Measurements: Length of the body: 155 mm.

Width of the body at the middle: 21 mm.

Holothuria scabra Jäger

FIGURE. 16.

Holothuria scabra, Jager, De Holothuriis, 1833, p. 23.

Holothuria scabra, Lampert, Die Seewalzen, 1885, p. 69.

- Holothuria scabra*, Theél, "Holothuridea", II, Rep. Sci. Res. "H.M.S. Challenger", Zoology, XIV, 1886, p. 234.
- Holothuria scabra*, Sluiter, Die Holothurien der Siboga Expeditie, 1901, p. 11.
- Holothura scabra*, Sluiter, Holothurien, in: Semon, Zool. Forschungs-reisen in Australien, 1894, p. 103.
- Holothuria scabra*, Sluiter, Die Holothurien Sammlung des Musuems zu Amsterdam (Bijdr. Dierk, XVII, 1894, p. 78.
- Holothuria gallensis*, Pearson, in Herdman's Pearl Oyster Rpts., 1903, pp. 203—204, pl. iii figs. 46 to 50.
- Holothuria gallensis*, Konningsberger, Tripang, en Tripangvijscherij in Nederlandsch-Indie (Med. Plantentuin, Java, LXXI, 1904, p. 52.
- Holothuria galle sis*, Koehler and Vaney, "Holothuries recui elles par l'Investigator dans l'Océan Indien", Calcutta, II, 1908, p. 16.
- Holothuria gallensis*, Gravely, "Littoral Fauna of Krusadai Island, in the Gulf of Manaar". Bull. Madras Government Musuem, Natural History, I, No. 1, 1927, p. 165.
- Holothuria gallensis*, described as a new species in Pearson (*loc. cit.*), is a synonym for *Holothuria scabra*.

Although this species does not ordinarily attain the length of *Holothuria atra*, yet it is much bulkier, and large specimens of this species collected from the Pamban area are about a foot in length and nearly four inches in diameter. The colour is rather variable. The dorsal surface varies from grey to almost black, and traversed by transverse yellowish streaks, but these are not so extensive in any of the specimens represented in the Museum collection as in the one figured by Pearson (*loc. cit.*, pl. iii, fig. 46). In the smallest specimens (about 5 centimeteres long), the yellow streaks are scarcely visible, and in a slightly larger specimen from Kutikal (in the Gulf of Manaar), reported by Dr. Gravely (*loc. cit.*, p. 165), they are entirely absent and the ventral surface is much speckled with dark grey.

Pearson (*loc. cit.*, p. 208) records three specimens of this species from the lagoon inside the Reef, Galle Coast, Ceylon (Lengths: 230 mm., 150 mm., and 70 mm.).

There are twenty tentacles, and in the specimens from Ceylon examined by Pearson, only the 20 tentacular ampullae are reported to have been present, the tentacles themselves having been lost.

The body is divided into a distinct dorsal and ventral surface. The dorsal surface is black or dark grey and is crossed by numerous conspicuous transverse yellow streaks. The pattern, however, varies somewhat in different specimens, the yellow streaks in the smallest ones not being very evident. On the ventral surface, the colour is light yellow, mottled all over with small grey patches.

The ambulacral appendages consist of papillae both on the dorsal and ventral surfaces. On the dorsal surface there are small papillae, which are very thickly scattered and inconspicuous. The appendages on the ventral surface are much more numerous; and are easily distinguished because each one is generally situated in the centre of a dark grey patch. These appendages which are mostly retracted in preserved specimens, are evidently true pedicels. They have only a small terminal plate, and they are strengthened by spicules similar to those found in the general integument.

The mouth is ventral, and is surrounded by a small crown of papillae. There are no anal teeth.

The deposits closely agree with those described by Pearson for Ceylon specimens. The deposits consist of two kinds: (1) closely packed tables having, in the older specimens, a large, central hole and about eight smaller peripheral holes. This is surmounted by a spire having four upright bars. The spire terminates in a round top, having numerous spines; and (2) knobbed buttons, having generally three pairs of holes. These buttons have normally two knobs, and three pairs of perforations, but in the smaller specimens, many of them are longer, with more numerous knobs and perforations, the knobs being less regularly disposed.

The tables are large, with two rows of teeth on the terminal ring of the spire. Pearson (*loc. cit.*, p. 203) reports that the tables in the smallest specimens are much better developed than in the older ones, but this difference is not very evident in the Pamban specimens.

The buttons in the youngest specimens have about five pairs of holes, whilst those in the older specimens invariably have only three.

The calcareous ring is simple, like that of any tropical member of the family Holothuriidae (= Aspidochirotae). There are two long Polian vesicles. No stone canals are seen.

Holothuria scabra seems to prefer the same type of habitat as that of *Holothuria atra*, and they are often found together although as a rule, *Holothuria scabra* is much less abundant in the Pamban area, around Krusadai Island.

Holothuria scabra is sufficiently common especially around the Ceylon Coast to be of commercial importance for being used for the preparation of "Trepang". On account of its mottled appearances, it has often been confused with *Holothuria marmorata* from which, however, it differs in many respects. The yellow transverse stripes on the dorsal surface and the mottling on the ventral surface are very characteristic of *Holothuria scabra*.

Recorded localities.—This species has been recorded from several stations in the Indo-Pacific Region covered by the Siboga Expedition, from the lagoon inside the Reef on the Galle Coast, Ceylon (Pearson), from the Andaman Islands and the Mergui Archipelago (Koehler and Vaney) and from around Krusadai Island in the Gulf of Manaar (Gravely).

Specimens in the collection:

I. Reference Collection:

(1) Two specimens: Locality: Krusadai Island in the Gulf of Manaar, 1925.

Both the specimens are faded almost uniformly dirty greyish white. The surface is covered by numerous wart-like papillae which are more numerous and closely crowded on the ventral surface. The surface (especially the dorsal surface) is strongly transversely wrinkled. The integument is thick and leathery and the tentacles are contracted in both the specimens. The body is somewhat flattened.

Measurements: (i) of the larger specimen:

Length of the body: 172 mm.

Width of the body at the middle: 68 mm.

(ii) of the smaller specimen:

Length of the body: 142 mm.

Width of the body at the middle: 71 mm.

(2) One small specimen: Locality: Krusadai Island, in the Gulf of Manaar, September, 1944.

The specimen is bleached almost completely and uniformly greyish white on the dorsal surface and creamy white on the ventral surface. The papillae are wart like processes strongly developed and more numerous and crowded on the paler ventral surface. The tentacles are contracted and the integument is tough and leathery. The body is only slightly wrinkled transversely about the middle.

Measurements: Length of the body: 122 mm.

Width of the body at the middle: 43 mm.

II. Gallery Collection:

(3) One very large and bulky specimen is mounted and exhibited in the Gallery. Locality: Gulf of Manaar. This is by far the largest and bulkiest specimen in the collection. The dorsal surface is dull smoky grey and shows traces of the transverse yellowish white bands distinctly. The ventral surface is whitish, with the crowded, wart-like papillae.

Measurements: Length of the body: 222 mm.

Width of the body at the middle: 163 mm.

The circumference of the body of this specimen in the middle is 285 mm., or nearly a foot. The transverse yellowish white streaks are rather interrupted.

Holothuria vagabunda Selenka.

FIGURE 17.

- Holothuria vagabunda*, Selenka, *Bietrage zur Anatomie und Systematik der Holothurien*, 1867, pl. 334, p. xix, figs. 75 and 76.
- Holothuria vagabunda*, Bell, *Report on the Zoological Collections of the Voyage of "H. M. S. Alert,"* 1884, p. 509.
- Holothuria vagabunda*, Koehler, *Echinodermes de 'la baie d' Amboina* (Rev. Suisse Zool., t. III, 1895, p. 284.
- Holothuria vagabunda*, Koehler, *Echinodermes des Iles de la Sonde* (Mem. Soc. Zool. France, 1895, p. 383.)
- Holothuria vagabunda*, Whittlegge, *The Echinodermata of Funafuti* (Mem. Austral. Mus., III, 1896, p. 161).
- Holothuria vagabunda*, Ludwig, *Echinodermen des Sansibargebietes* (Abh. Senckenberg Ges., XXI, 1899, p. 558).
- Holothuria vagabunda*, Bedford, "Holothuriens", A. Willey' *Zoological Results*, Part II, 1899, p. 145, pl. xviii.
- Holothuria vagabunda*, Bedford, *Report on the Holothurians collected by M. J. Stanley Gardiner at Funafuti and Rotuma*, Proc. Zool. Soc. London, 1898, p. 842.
- Holothuria vagabunda*, Sluiter, *Die Holothurien der Siboga-Expeditie*, 1901, p. 12.
- Holothuria vagabunda*, Semper, "Holothurien", *Reisen im Archipel der Philippinen* (2), I, (Weisbaden, 1868), p. 81.
- Holothuria vagabunda*, Pearson, *Report on the Holothuroidea collected by Prof. Herdman at Ceylon, in 1902. Report on the Ceylon Pearl Oyster Fisheries, Part I, Supplementary Report, V*, 1903, p. 201.

Holothuria vagabunda, Konningsberger, Tripang en Tripangvisserij in Nederland-sch-Indie (Med. Plantentuin, Java, LXXI, 1904, p. 50, pl. viii).

Holothuria vagabunda, Theél, "Holothuridea", Part II, Rep. Sci. Res., H.M.S. "Challenger", Zool. XIV, 1886, pp. 180, 218.

Holothuria vagabunda, Koehler and Vaney, "Holothuries recueilles par l'Investigateur dans l'Océan Indien", Calcutta, II, 1908, p. 17.

This is a widely distributed species and is represented in the Museum collection by one specimen from Tuticorin and one from Kutikal, Rameswaram, in the Gulf of Manaar, but has not been previously recorded by Dr. Gravelly in his "Littoral Fauna of Krusadai Island, in the Gulf of Manaar", Bulletin of the Madras Government Museum, I, No. 1, 1927.

This species attains a fairly large size. Pearson (*loc. cit.*, p. 201), reports one specimen of this species from the lagoon inside the Reef, Galle, Ceylon. Its length is recorded as 180 mm. The colouration of this species varies from greyish white to maroon, more or less dark. The pedicels have a more reddish colour than the general ground colour. In the specimens of large size from the Persian Gulf, examined by Koehler and Vaney, the dorsal surface is freckled or speckled with dark bands, elongated longitudinally.

Koehler and Vaney further report (*loc. cit.*, p. 17) that the specimens examined by them from the Andamans, Laccadives, etc., vary in length between 40 and 140 mm., and their colouration is reported to vary from greyish white to maroon, more or less dark. The pedicels are said to have a more reddish colour than the general ground colour.

The ambulacral appendages consist of pedicels. Theél (*loc. cit.*, pp. 180, 218) is uncertain as to the exact nature of the ambulacral appendages on the dorsal surface. He states that they may be considered either as pedicels or papillae. Some of them have a more or less obviously conical form and resemble papillae, while others are more cylindrical; a closer examination reveals that the former are devoid of a true sucking disc, have the terminal plate very rudimentary and the walls strengthened by numerous spinous transverse rods, while the latter have a small, though distinct, sucking disk, a much larger terminal plate and comparatively few supporting rods; these rods are only concentrated around the terminal plate, and are not distributed over a greater area as is the case in the papillae, and, like those in the ventral pedicels they generally resemble elongated plates, with two more or less incomplete rows of perforations or bilaterally symmetrical, fenestrated, more or less elongated plates.

Theél further reports that in all the specimens examined by him in the Challenger collections from the various localities (see under "Recorded localities") the ambulacral appendages appear to be of nearly equal size on the dorsal and ventral surfaces: but the ventral ones are cylindrical, and the dorsal more papilliform. The ventral ones are reported to have a well developed terminal plate and bilaterally symmetrical perforated supporting plates; the dorsal are said to have a rudimentary terminal plate and numerous simple spinous or slightly branched or even perforated rods. Besides, the ventral appendages are always more numerous than the dorsal. In the forms examined by Theél the dorsal appendages are described as forming a transition between pedicels and true papillae, thus making it rather difficult to draw a distinction between them. The colour of the Challenger specimens is reported to vary from dark brown to light reddish brown. The Cuvierian organs are strongly developed in this species and reported to be of a violet or reddish colour.

The dorsal ambulacral appendages are of two kinds, namely, pedicels and papillae. The ventral appendages are slightly more numerous than the dorsal ones. The ambulacral appendages appear to be of nearly equal size on the dorsal and ventral surfaces, but the ventral ones are cylindrical, and the dorsal more papilliform.

There are about eighteen tentacles. A single madreporic canal is reported. The polian vesicles are said to range from one to three in number. The Cuvierian organs are reported to be strongly developed in this species and are of a violet or reddish brown colour.

The deposits consist of tables and buttons. The tables are usually not with very large disks, and with the spire terminating in eight to ten teeth placed around the nearly circular aperture in its top. Scattered among these common tables others are found with their spires much more tapering towards the apex which becomes very narrow and comparatively insignificant. The disks of the tables are often uneven in the margins and even spinose, but there are many disks to be found which have the margins rounded, smooth and slightly undulating. The buttons are of the usual shape, generally with six holes, but it is not unusual to find them with eight apertures, especially in the papillae. The dorsal pedicels alone have supporting rods which are spinous and tapered towards the ends. The disks and tables are sometimes not very well developed, sometimes round or angular, with a large central hole, and several peripheral ones, and their margin is often uneven.

Bedford (in Willey's Zoological Results, *loc. cit.*, 1899. p. 145) records two small specimens of this species from Lifu, Loyalty Islands measuring 41 mm. and 22 mm. in length, respectively. Bedford reports that the deposits in these specimens agree with the typical pattern described by Theél for this species in his Challenger Reports. The disks of the tables are reported to vary from 0.1 mm. to 0.4 mm. in diameter, and the spire is also said to vary in length considerably. The tables with small disks are provided, as a rule, with a short, thick, spire, while in the larger tablets, the spire is narrower and longer and rarely more than one transverse bar can be seen. The crown is observed to nearly always carry eight teeth and some of the small disks are said to be uneven or even spinous in the margin. The buttons are reported to be sometimes somewhat irregular. The Cuvierian organs are described as large and whitish in the spirit-preserved specimens reported by Bedford.

Bedford also refers to two more specimens from Lifu, Loyalty Islands. 10.5 cm. and 5.1 cm. in length, which he thinks are also probably referable to this species. But slight variations in the deposits were observed in these specimens. The deposits in these specimens differed from those in the typical forms in that the tables did not vary much in size, the disk was smooth, uneven or spinous and the crown bore 10-12 teeth which were generally irregular. One of these specimens was reported to contain one very large Polian vesicle, one free Stone canal and Cuvierian organs.

Recorded localities.—This is a widely distributed species and has been recorded from distantly separated localities by various authors. Pearson (*loc. cit.*, p. 201) has cited the geographical distribution of this species as ranging over East Africa, Indian Ocean, East Indies, Hong Kong and the Pacific Islands. Koehler and Vaney (*loc. cit.*, p. 17) have recorded specimens of this species from the Andaman Islands, Persian Gulf, Grande Coco Island and the Laccadive Islands. Bedford (*loc. cit.*, p. 145) records it from Lifu, Loyalty Islands and Theél, in his Challenger Reports (*loc. cit.* pp. 180, 218) records it from Tongatabu (Friendly Islands), Samboangen (Philippine Islands) and Fiji Islands. Pearson (*loc. cit.*, p. 201) reports one specimen of this species from the lagoon inside the Reef, Galle, Ceylon; its length is recorded as 180 mm.

Theél (*loc. cit.*, p. 219) cites the following localities as representing the range of distribution of *Holothuria vagabunda*:—

Sandwich Islands and Society Islands (Selenka); Philippine Islands, Mac Keen's Islands, Sunda Islands, Mozambique and Aden (Semper); Zanzibar (Selenka); Java (Selenka, Ludwig); Navigator Islands (Semper, Ludwig); Nicobar Islands and Hong Kong (Ludwig); Dorros Iland (Bell); Ualen (Brandt); Bowen (Ludwig). Moreover, Theél reports that the Godeffrov Museum has specimens of this species from the following localities: Tahiti, Massua, Eooa, Fiji Islands, Rockhampton and New Britain.

Semper (*loc. cit.*, p. 81) adds the following to the list of collection sites recorded for this species. Samoa Islands (Graffe), Mac Keen's Islands, Philippines, Sunda Islands and Mozambique (Berlin Museum).

Specimens in the collection.—Two specimens are represented in the Museum's reference collection. Both are short, thick and robustly built, with a thick, tough integument.

(i) One specimen. Locality: Kutikal, Rameswaram. The specimen is dull greyish brown and strongly transversely wrinkled and furrowed.

Measurements :

Length of the body : 81 mm.

Width of the body in the middle : 34 mm.

(ii) One specimen. Locality: Tuticorin. The specimen is dull ashy grey and deeply furrowed transversely, but not so closely as in the preceding specimen. The specimen has been cut right through, longitudinally, perhaps for a study of the internal organs.

Measurements :

Length of the body : 120 mm.

Width of the body at the middle : 38 mm.

Holothuria marmorata (Jäger).

FIGURE 18.

Bohadschia marmorata, Jäger, de *Holothuriis*, 1883, p. 18.

Holothuria marmorata, Lampert, *Die Seewalzen*, 1885, p. 86.

Holothuria marmorata, Semper, "Holothurien" *Reisen im Archipel der Philippinen* (2) I, (Weisbaden), 1868.

Holothuria brandtii, Selenka, *Beiträge zur Anatomie und Systematik der Holothurien*, 1867 and 1868.

Holothuria marmorata, Sluiter, *Die Holothurien der Siboga-Expedition*, 1901, p. 12.

Holothuria marmorata, Théel, "Holothuridea", Part II, *Rep. Sci. Res., "H.M.S. Challenger"*, Zoology, XIV, 1868, pp. 180, 218.

Holothuria marmorata, Pearson, *Report on the Holothuroidea collected by Prof. Herdman at Ceylon, in 1902, Report on the Ceylon Pearl Oyster Fisheries Pt. I, Supplementary Report*, V, 1903, p. 201.

This species is represented in the Museum Collection by a single specimen collected from Rameswaram, and has not been previously recorded in the earlier Bulletins of this Museum dealing with the littoral Holothurians of Krusadai Islands and Pamban areas or with the Madras Beach fauna.

This species seems to be a fairly widely distributed one in the Indo Pacific Region and its distribution seems to range from the Philippine and Fiji Islands in the East to Mauritius and Caroline Islands in the West.

Théel bases his description of this species on a specimen from Mauritius in the "Challenger" collections. The colour in the living condition is described as auburn on the dorsal surface with some large spots or bands of yellowish white colour and yellowish white on the ventral surface. Pearson (*loc. cit.*) referring to a specimen collected from the lagoon inside the Reef on the Galle Coast in Ceylon describes its colour in spirit as being dark brown with a violet tinge on the ventral surface, and

the dorsal surface as being lighter, especially at the posterior end. The colour on the dorsal surface is said to be not uniform, but the Ceylon specimen is reported to be devoid of the striped and spotted appearance that is characteristic of the species.

In typical specimens when fresh, a large, darker violet spot may be found here and there, especially along the sides of the body, within a light yellowish space. The ambulacral appendages have the form of cylindrical pedicels, scattered all over the body the skin being considerably darker at the base of each pedicel. The pedicels, however, are smaller on the dorsal surface. These pedicels are supported by a well developed terminal plate and numerous transverse rods. Scattered among the dorsal pedicels, other ambulacral appendages are often found which are slightly larger than the dorsal pedicels themselves and are of a more conical form and may be regarded as papillae. These papillae are supported by a good number of rods, but their terminal plates are very much reduced. According to Selenka, the ambulacral appendages are devoid of supporting rods.

The rosettes in the body wall are mostly very incompletely developed, either resembling simple X-shaped bodies or oval grains with incisions at their middle, or rounded grains with or without perforations, or even rods with a series of rounded prominences on each side.

A single Polian vesicle and madreporic canal are present. The anterior portion of the interradical pieces of the calcareous ring is rounded and knob-like. Cuvierian organs are well developed.

The anus is pentagonal or stellate and is surrounded by five groups of papillae, each group consisting of five papillae.

Pearson (*loc. cit.*, p. 202) referring to the specimen of this species from Ceylon, reports that this species is very similar in most respects to *Holothuria tenuissima*. However, it is said to differ slightly from that species in the nature of the deposits, the spicules not dichotomising to such an extent, but having rather the appearance of perforated granules. The papillae around the anus are also reported to be more prominent than in *H. tenuissima*. But since the similarities are very close, in spite of these differences, Pearson feels that they may prove to be varieties of one and the same species.

Recorded localities.—This species is widely distributed in the Indo-Pacific Region generally. Théel (*loc. cit.*, p. 202) records this species from Philippine Islands (Semper), Nicobar Islands (Semper), Java (Selenka), Celebes (Jäger), Fiji Islands (Semper), Amboina (Ludwig), Geelvink Bay at New Gunia (Ludwig), Mauritius (Haacke and Ludwig), Bonin Islands (Semper), Caroline Islands (Brandt), in his "Challenger" Reports.

Pearson (*loc. cit.*), records one specimen of this species from the lagoon inside the Reef in Galle, Ceylon in the Gulf of Manaar and the single specimen of this species represented in the Madras Museum collection is from Rameswaram in the Gulf of Manaar.

Specimens in the collection.—One wet-preserved specimen is represented in the Museum's Reference Collection. Locality: Rameswaram, in the Gulf of Manaar.

The specimen is bleached and faded into a dirty greyish white colour and is closely and strongly transversely wrinkled and the surface consequently presents a coarse and roughly tuberculated appearance. The integument is thick, tough, coarse and leathery. The specimen has been partly slit open longitudinally on the ventral side, probably to facilitate study of the internal parts. The pedicels are contracted and are smaller and more closely crowded on the dorsal side. A fine, thread-like median longitudinal groove extends from the mouth to the anus on the dorsal surface. The anus is distinctly star-shaped (or stellate) in appearance.

The body is rather short, broad and thickly built.

Measurements: Length of the body: 100 m.m.

Width of the body in the middle: 48 mm.

Family STICHOPODIDAE.

The members of this family possess long, tentacular ampullae and an extensive rete mirabile involving the left respiratory tree, but there are two gonadial tufts, one to each side of the dorsal mesentery.

Genus *Stichopus* Brandt.

This is the main genus of this family. The species of *Stichopus* are large, conspicuous, warty sea cucumbers, mostly of the warmer waters, with a warty or papillate dorsal surface and a flattened, creeping sole, bearing three bands of locomotory podia. In this genus, there are two bundles of genital tubes, one on each side of the dorsal mesentery. There are about eighteen to twenty tentacles. The body is quadrangular. The ambulacral papillae are placed on warts which are usually arranged in longitudinal rows. The belly (i.e., the ventral surface) is flattened, mostly with three well defined rows of tube feet (podia). Two tufts of genital follicles are found on the mesenterium.

The ambulacral appendages are in the shape of pedicels and papillae; the former are arranged in three more or less distinct longitudinal series on the ventral surface and the latter mostly situated on the tops of the larger or smaller protuberances, forming rows along the dorsal ambulacra, or scattered all over the dorsal surface. The anus is devoid of calcareous teeth. C-shaped deposits are often present in the peristome.

A single species, *Stichopus chloronotus*, is represented in the Museum collection, by specimens from Rameswaram and Kutikal in the Gulf of Manaar area.

Stichopus chloronotus Brandt.

FIGURE 19.

- Stichopus chloronotus*, Brandt, Prodrom, etc., 1835, p. 50.
- Stichopus chloronotus*, Brandt, V.E., Selenka, z.f.w.z., 17, 1867 p. 315—316; pl. xvii, figs. 20—24; pl. xviii, fig. 25.
- Stichopus chloronotus*, Ludwig, H. Sitzb. k. Akad. d. Wiss., Berlin, No. 54 (1887), p. 1224; pl. xv, fig. 4.
- Stichopus chloronotus*, Sluiter, C. Ph., Natuurk., Tijd., v. Ned. Ind. (1887), Bd. 47, p. 195.
- Stichopus chloronotus*, Lampert, K., Zool., Jahrb., Sy st., Bd iv, 1889, p. 815.
- Stichopus chloronotus*, Semper, "Holothurien", Reisen im. Archipel der Philippinen (2), I, (Weisbaden), 1868, p. 275.
- Stichopus chloronotus*, Bedford, Willey's Zoological Results, Part. II, 1899, p. 150.
- Stichopus chloronotus*, Koehler, Echinodermes de la baie d'Amboine. (Rev. Suisse Zool., t. III 1895, p. 285.)
- Stichopus chloronotus*, Koehler, Echinodermes des. Piles de la Sonde (Mem. Soc. Zool. France, 1895, p. 385).
- Stichopus chloronotus*, Sluiter, Die Holothurien der Siboga Expeditie, 1901, p.31.
- Stichopus chloronotus*, Theel, "Holothuridea", Part II, Rep. Sci. Res. "H.M.S. Challenger", Zoology, XIV, 1886, pp. 159—160 and 189—190; pl. vii. figs. a—8.

- Stichopus chloronotus*, Pearson, Report on the Holothuroidea collected by Prof. Herdman at Ceylon, Ceylon Pearl Oyster Fisheries Report, Part I, Supplementary Report, V, 1904, p. 204.
- Stichopus chloronotus*, Gardiner, Fauna and Geography of the Maldives and Laccadive Archipelago, I, 1904, p. 339.
- Stichopus chloronotus*, Koningsberger, Tripang en Tripangviss cherij (Med. Plantentium, Java, LXXI, 1904, p. 42).
- Stichopus chloronotus*, Koehler and Vaney, "Holothuries recueillies par l'Investigateur dans l'Océan Indien", Calcutta, II, 1908, p. 23.
- Stichopus chloronotus*, Gravely, "Littoral Fauna of Krasadai Island in the Gulf of Manaar", Bull. Madras Government Museum, Natural History, I, No. 1, 1927, p. 165.

This is a widely distributed species and has been recorded from various localities in the Indo-Pacific Region, and in the Gulf of Manaar area, specimens of this species have been collected from Kutikal and Rameswaram.

This species may be readily distinguished from all the other species of Holothurians from the Pamban area represented in the Museum collection by its two dorsal double rows and lateral single rows of large, conical tubercles, and by the presence of finely tapered, C-shaped spicules, which are characteristic of this species.

Theél (loc. cit., p. 159), referring to the "Challenger" specimens, reports that the colour of this species is normally olive brown. Koehler and Vaney (loc. cit., p. 23), however, referring to specimens he had examined from the Andamans, states that the colouration of this species in different specimens is very variable. Some of them are described as being greenish, others yellowish, and still others whitish. Their lengths are reported to range from 45 mm. to 180 mm. Most of the specimens present, on the dorsal radius, large papillae disposed in two more or less alternating rows, while on the lateral aradii, only a single row of these protuberences are reported to be present. Koehler and Vaney have recorded specimens of this species from Port Blair and the Andaman Islands.

Theél (loc. cit., p. 159) reports that the colour of this species in life is normally olive brown, but this is subject to variation. The tentacles are twenty in number. The mouth is surrounded by a crown of papillae. The dorsal ambulacral appendages are in the shape of conical warts or protuberences arranged in a double alternating row along each side of the body as well as along the dorsal ambulacra; their arrangement in a double row is more distinct in the dorsal ambulacra than on the sides. The odd interambulacrum and those of the sides of the body are naked. The ventral pedicels are crowded and their arrangement in longitudinal series is not said to be clear in the contracted specimens reported by Theél in his "Challenger" Reports. A single madreporic canal and three Folian vesicles are present.

The twenty tentacles, the papillae being placed on rather prominent conical warts, forming a double row along each dorsal ambulacrum, and a zig-zag or double alternating row along each side of the body are characteristic features of this species.

The deposits consists of numerous C-shaped bodies; in addition, tables are also present; besides, Theél (loc. cit., p. 159) reports that he has observed a very few incomplete rosettes or dichotomously branched bodies which were absent in the typical specimens examined by Selenka and others. Dr. Gravely (loc. cit., p. 165) mentions that in the preparation made from the Gulf of Manaar specimens, such bodies were found to be numerous. The spire of the tables terminates in eight to twelve teeth.

The pedicels contain spinous rods which are mostly enlarged and perforated at their middle. The dorsal appendages are also strengthened by numerous curved, simple or branched rods. The presence of the rosettes is pointed out as being the only difference from the condition in the typical forms. Theel feels that possibly they are peculiar to the specimens from the concerned Stations referred to in the "Challenger" Reports, or they might have escaped the previous observers on account of their scarcity.

Pearson (*loc. cit.*, page 204), also records one specimen of this species from East Cheval Paar, $5\frac{1}{2}$ fathoms deep. The length is noted as 140 mm. This specimen (reported by Pearson from Ceylon) agrees very closely with Theel's description. There are, however, only 19 tentacles in the Ceylon specimen recorded by Pearson. There are four longitudinal series of protuberences on the dorsum, the two dorsal series being double, while the two ventral series have a more or less zig-zag arrangement. The pedicels are described as being irregularly distributed over the ventral surface. Professor Herdman's notes state that the body was of a dark green colour when alive.

Pearson (*loc. cit.*, pages 204-205), also records a distinct variety of this species, namely *Stichopus chloronotus* var. *fuscus* from Pearl Banks, Gulf of Manaar. He has described this as a new variety, based on three specimens taken from a depth of 9-26 fathoms at Pearl Banks. The lengths are reported to be respectively 170 mm., 200 mm., and 110 mm. The mouth is surrounded by a crown of papillae. The number of tentacles is reported to be different in each specimen (eighteen in the largest, fourteen in the next and sixteen in the smallest). But in the two smaller specimens it is probable that some tentacles are retracted.

Four irregular rows of protuberences are reported to be present—one row along each side of the body. In this it differs from the typical form of *Stichopus chloronotus*, which has two double rows on the dorsal surface. The pedicels are irregularly scattered on the ventral surface showing a slight indication of forming three rows.

The deposits are said to agree with those of *Stichopus chloronotus* s. str., except that the C-shaped deposits are very scarce.

The specimens of this variety in spirit are reported to be very much darker in colour than the spirit specimens of *Stichopus chloronotus* s. str., former being of a dark chocolate brown colour.

Pearson feels that the differences between these specimens and the typical form of *Stichopus chloronotus* justify the formation of a new variety.

Recorded localities.—This is a widely distributed species and has been recorded from various localities in the Pacific Islands, Indian Ocean from East Africa to Malay Peninsula, Andaman Islands, Port Blair in the Andamans, Lifu, Loyalty Islands and from Kutikal and Rameswaram in the Gulf of Mannar.

Theel (*loc. cit.*, p. 159) records some specimens from Friendly Islands and Fiji Islands. In addition, the following locality records have been cited for this species: Zanzibar (Selenka), Querimba and Mozambique (Semper), Indian Ocean (Ludwig), Mauritius (Haecke, Ludwig), Macassar (Ludwig), Lugunor and Guahan (Brandt), Sandwich Islands (Selenka), Pulo Tikul, Nicobar Islands, Pelew Islands, Molucca Islands, Navigator and Fiji Islands (according to Semper), Darros Islands (Bell).

In addition, Theel reports many specimens from unknown localities. In addition to the C-shaped deposits and tables, Theel has observed some very scattered, incomplete rosettes in these specimens.

Specimens in the collection.—Several wet-preserved specimens are represented in the Museum collection. Most of them are collected from Rameswaram, in the Gulf of Manaar, where this species appears to be fairly common especially in the soft, sandy bottom of the shallow lagoons in and around Rameswaram Island. Of these specimens, two are exhibited in the Gallery and the remaining are contained in the Reference Collection.

1. *Gallery Collection*:

Two specimens. Locality: Rameswaram, Gulf of Manaar. The specimens are uniformly dirty whitish grey. The large, button-like conical tubercles on the dorsal surface and sides of the body are conspicuous and the ventral surface is coarsely covered with numerous, close-set, minute papillae, and the surface as a whole is conspicuously transversely furrowed. The tentacles are rather contracted.

Measurements.—(i) of the larger specimen:

Length of the body: 102 mm.

Width of the body at the middle: 32 mm.

Height of the body at the middle: 19 mm.

(ii) of the smaller specimen:

Length of the body: 74 mm.

Width of the body at the middle: 30 mm.

Height of the body at the middle: 14 mm.

II. *Reference Collection*:

(1) Six specimens, wet-preserved. Locality: Rameswaram, Gulf of Manaar.

The specimens are uniformly greyish brown. Five of these were collected in 1925, while the remaining one was collected in 1943.

The large, conical tubercles on the back and sides of the body are conspicuous and the entire surface is strongly transversely furrowed. The ventral surface is formed into a welldefined, flattened sole, bearing numerous, closely crowded papillae. The specimens vary in size, length and in the proportions of their lengths to their widths.

Measurements (i) of the longest specimen:

Length of the body: 104 mm.

Width of the body at the middle: 25 mm.

Height of the body at the middle: 15 mm.

(ii) of the broadest specimen:

Length of the body: 88 mm.

Width of the body at the middle: 35 mm.

Height of the body at the middle: 20 mm.

(iii) of the shortest specimen:

Length of the body: 59 mm.

Width of the body at the middle: 24 mm.

Height of the body at the middle: 15 mm.

(2) One small specimen, wet-preserved. Locality: Kuitkal, Gulf of Manaar, 1925.

The specimen is brownish grey and rather contracted. The tentacles on the back and sides of body are rather contracted and flattened in this specimen.

Measurements: Length of the body: 51 mm.

Width of the body at the middle: 18 mm.

Height of the body at the middle: 20 mm.

ORDER MOLPADONIA

The Molpadonia are mostly stout, relatively smooth sea cucumbers of some size, with the posterior region usually narrowed to simulate a tail, containing the elongated cloaca and bearing the anus at its tip. The terminal anterior end forms a flat, circular disk provided with fifteen (ten in one genus) digitate tentacles, simple or with fingers. The tentacles usually have free tentacular ampullae. Radial water vascular canals are present, but podia are lacking, except in *Gephyrothuria*, in which a few, widely spaced, very slender papillae occur on the mid-dorsal interradius. The radial canals terminate posteriorly in small anal papillae. Respiratory trees are present. The gonad occurs as two tufts of simple or branched tubules. Because of the lack of podia, the Molpadonia and the Apoda are known as apodous Holothurians.

Family MOLPADIDAE

The tentacles are simple, unbranched or digitate. Body tapering posteriorly into a narrow, longer or shorter caudal portion. The deposits are of various shapes. Anchors of a strange shape and appearance very seldom occur. "Wheels" are never present.

The main genus of the family is *Molpadia* and the single unidentified species represented in the Museum collection belongs to this genus.

Genus *Molpadia* Cuvier 1817; Semper 1888.

(= *Akyroderma*).

(= *Trochostoma*).

The members of this genus possess a well developed caudate region. This genus is characterized by the form of the tentacular digits; these occur as one to three side pairs and a large, unpaired terminal finger. Retractor muscles are present. The calcareous ring is provided with five bipartite posterior prolongations. The tentacles are twelve to fifteen in number and are branched and digitate. The calcareous deposits are in the form of knobbed or spinous, perforated, roundish button-like discs.

A single unidentified specimen labelled *Molpadia* sp. was represented in the Museum collection, but this specimen is unfortunately not now traceable in the collection.

ORDER APODA

The Apoda are Holothurians with a cylindrical or fusiform body and totally devoid of podia, except for the tentacles. They are modified, vermiform Holothurians with rough or warty surface. The tentacles, ten to twenty, or even more in number, are simple, digitate or pinnate; shortened, pinnate tentacles grade into the digitate type. Tentacular ampullae are wanting, and the tentacular canals spring directly from the water vascular ring; there are no radial canals. In correlation with the vermiform shape of the body, the loops of the digestive tract are much reduced or even almost wanting. There are no respiratory trees. The gonad consists of one pair of more or less branching tubules that are often hermaphrodite. Anchor and Wheel spicules are characteristic of this Order.

The single species of this order represented in the Museum collection belongs to the family Synaptidae, which is included in the Suborder Apneumona.

SUBORDER APNEUMONA

The respiratory trees are absent. Ciliated cups, attached to the mesenteries are present. Radial ambulacral vessels are absent.

Family SYNAPTIDAE

In this family there are no "Wheel" or sigmoid ossicles and the tentacles are always more or less pinnate or digitate. Anchor spicules with anchor plates are conspicuous in the thin body wall. Members of this family are often excessively elongated, and when fully extended, may reach lengths of two or three feet. The body is cylindrical. Only a single genus, *Synapta*, is represented in the Museum collection.

Genus *Synapta* Escholtz.

The tentacles are ten to twenty-five in number, digitate or pinnate, but their number is usually limited to fifteen. The deposits consist of anchors, anchor plates and miliary granules. In this genus, there is found immediately behind the calcareous ring another supporting ring, called the cartilaginous ring, composed of dense connective tissue. Members of this genus are hermaphrodite. This genus includes worm-like **Holothurians** characterized by the presence of "Anchor" spicules in the skin and ten to twenty-five finger-like or feather-like tentacles.

Only a single species of this genus, namely, *Synapta recta*, collected from the Pamban area in the Gulf of Manaar, is represented in the Museum collection.

Synapta recta Semper.

FIGURE 20.

- Synapta recta*, Semper, "Holothurien", Reisen Archipel. der Philippinen (2) I (Weishaden, 1868), p. 14, pl. IV, figs. 2 and 3.
- Synapta recta*, Theél, "Holothuridea", II, Rep. Sci. Res. "H.M.S. Challenger", Zoology XIV, 1886, p. 24.
- Synapta recta*, Sluiter, "Fauna des Java-Merres", Nat. Tij. v. Ned. Indie, XLVII, 1887.
- Synapta recta*, Bedford, Holothurians, A. Willey's Zoological Results, Part II, 1899.
- Synapta recta*, Pearson, Report on the Holothuroidea collected by Prof. Herdman, Ceylon, Ceylon Oyster Fisheries Report, Part I, Supplementary Report V, 1904, p. 186, pl. i, fig. 1.
- Synapta recta*, Gravely, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bull. Madras Government Museum, Natural History, I, No. 1, 1927, p. 168,

This species was originally represented in the Museum collection by a single specimen collected from Pamban, which was found under the Pamban Bridge and referred to by Dr. F.H. Gravely in his account of the Echinodermata of Krusadai Island (*loc. cit.*, 1927, p. 168). Subsequently more specimens of the same species have been collected from Pamban, Pamban Bridge, Rameswaram and Madras and these are now contained in the Museum collection. The distribution of this species had been originally recorded as Java, Ceylon and Bohol, but the occurrence of the species in Pamban, Rameswaram and Madras has therefore since extended its recorded range of distribution to the East Coast of South India and to the Gulf of Manaar area in South India also. The specimens of this species collected from Pamban are slender, purplish creatures about 60 mm. in length and very active when alive. Smaller, similar specimens are abundant at Rameswaram.

Pearson (*loc. cit.*, p. 186) records eight specimens of this species from the outer part of Yard Cave, Trincomalee (Station XXVI), at a depth of 2—8 fathoms. Their lengths are reported to range from 15 mm. to 85 mm., and the smaller specimens are evidently in a contracted condition.

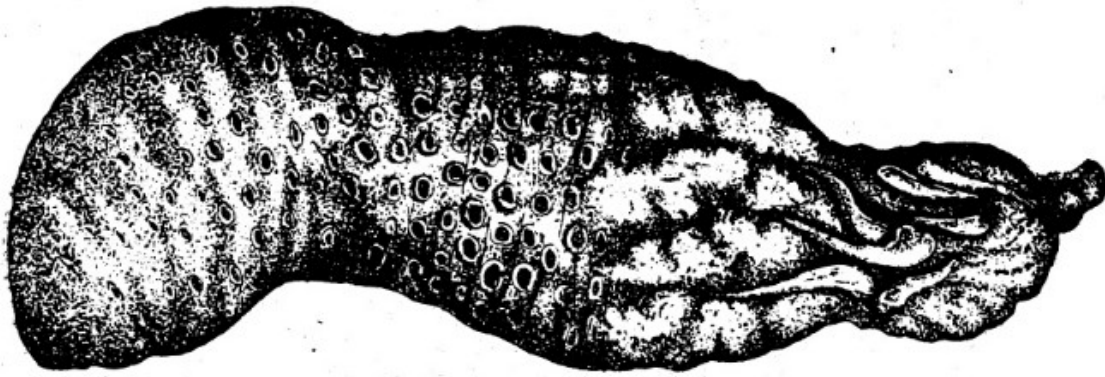


Fig. 4. *Cucumaria conjugens* Semper.
($\times 10$).

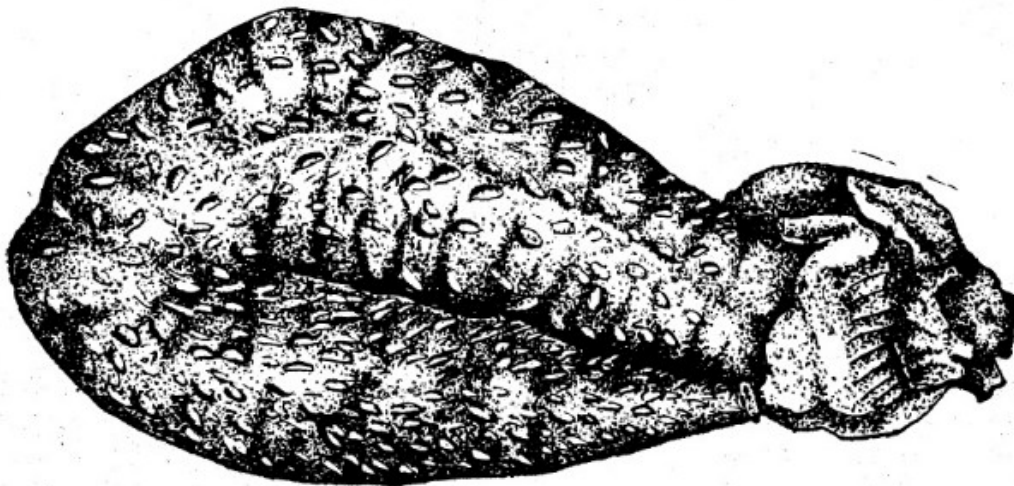


Fig. 5. *Cucumaria frauenfeldi* Ludwig.
($\times 5$).

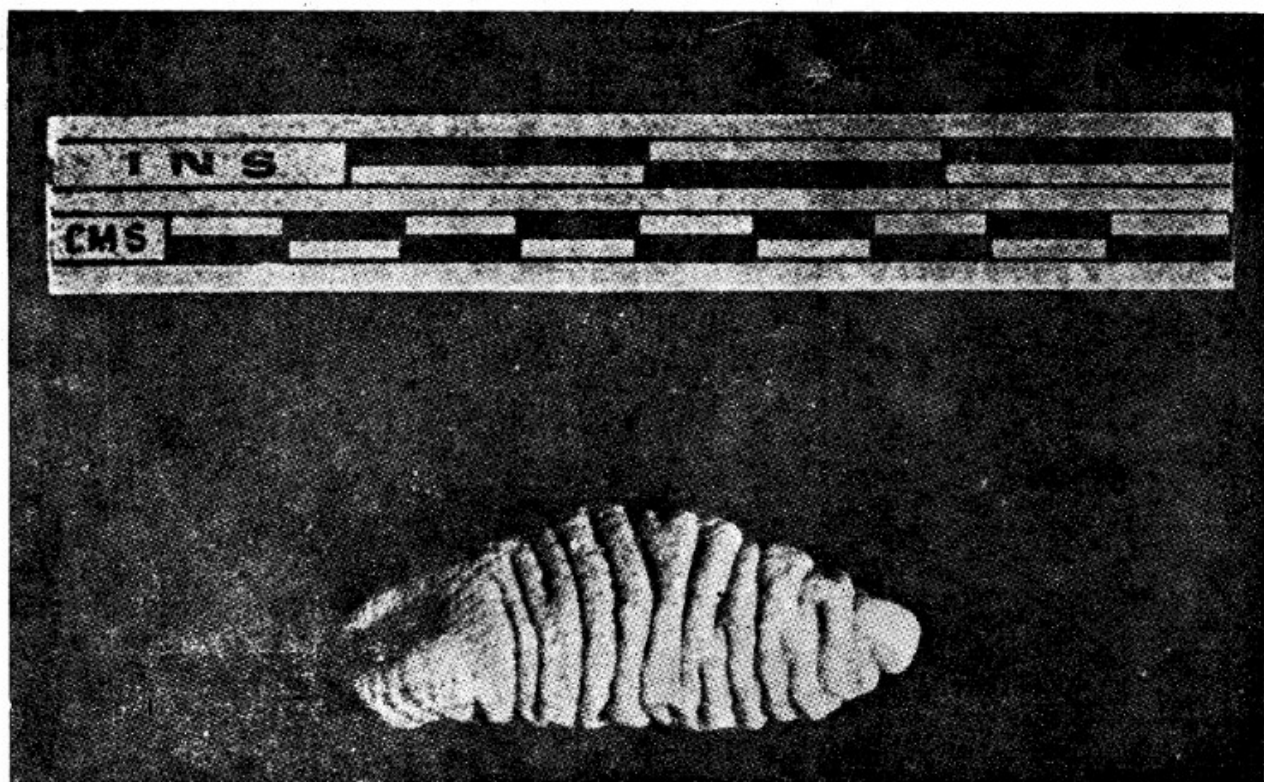


Fig. 6. *Stolus buccalis* (Stimpson).

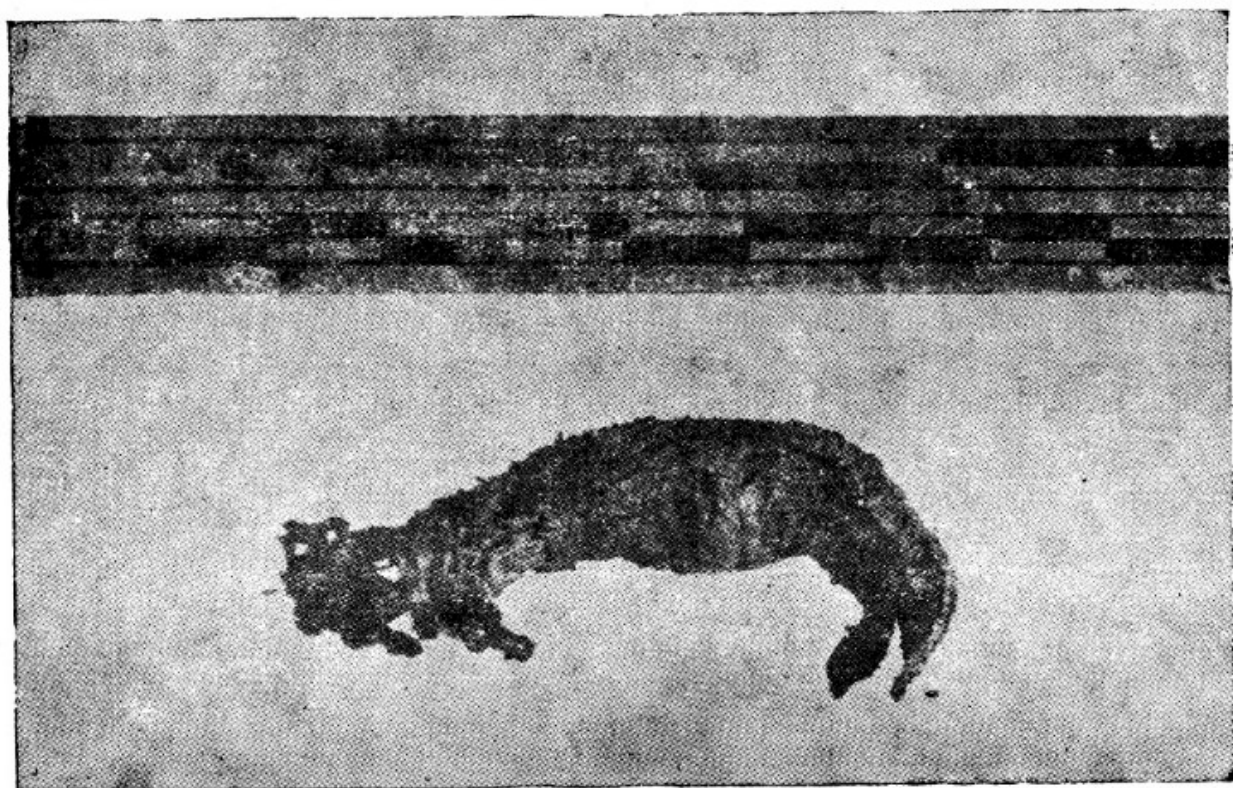


Fig. 7. *Thyone mirabilis* Ludwig.

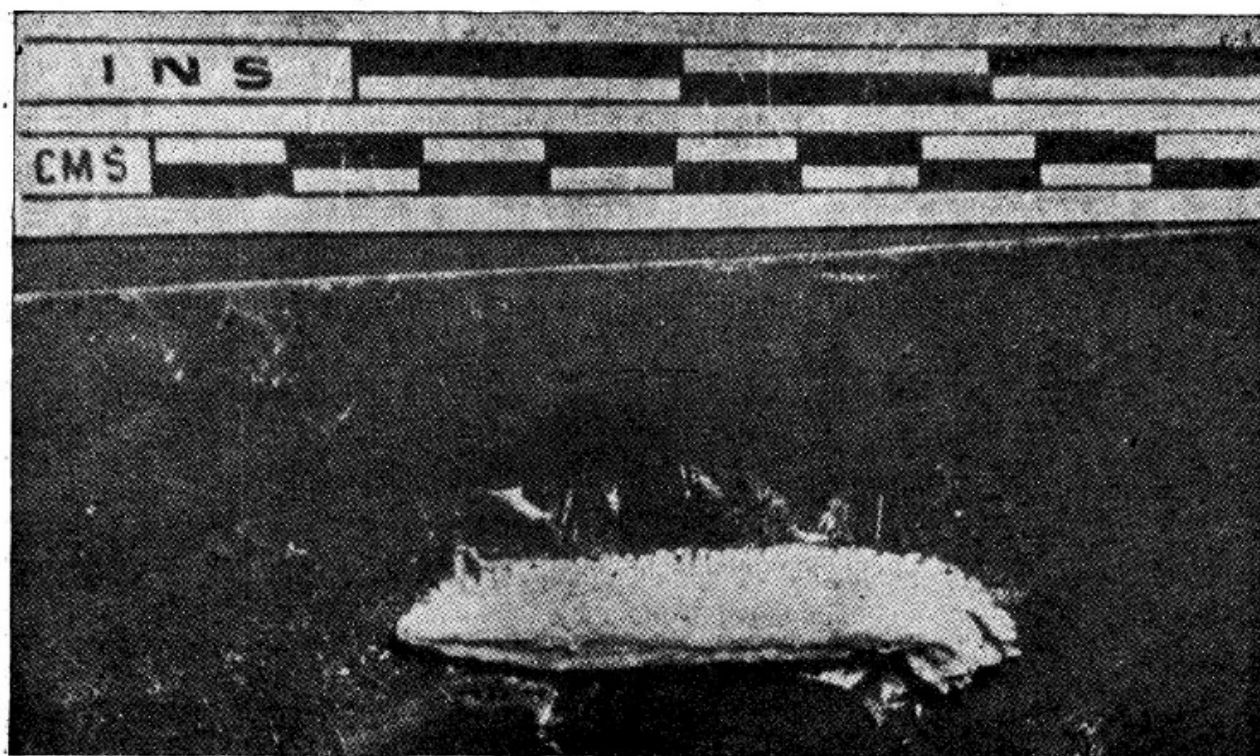


Fig. 8. *Actinocucumis typica* Ludwig.
(= *Actinocucumis difficilis* Bell).

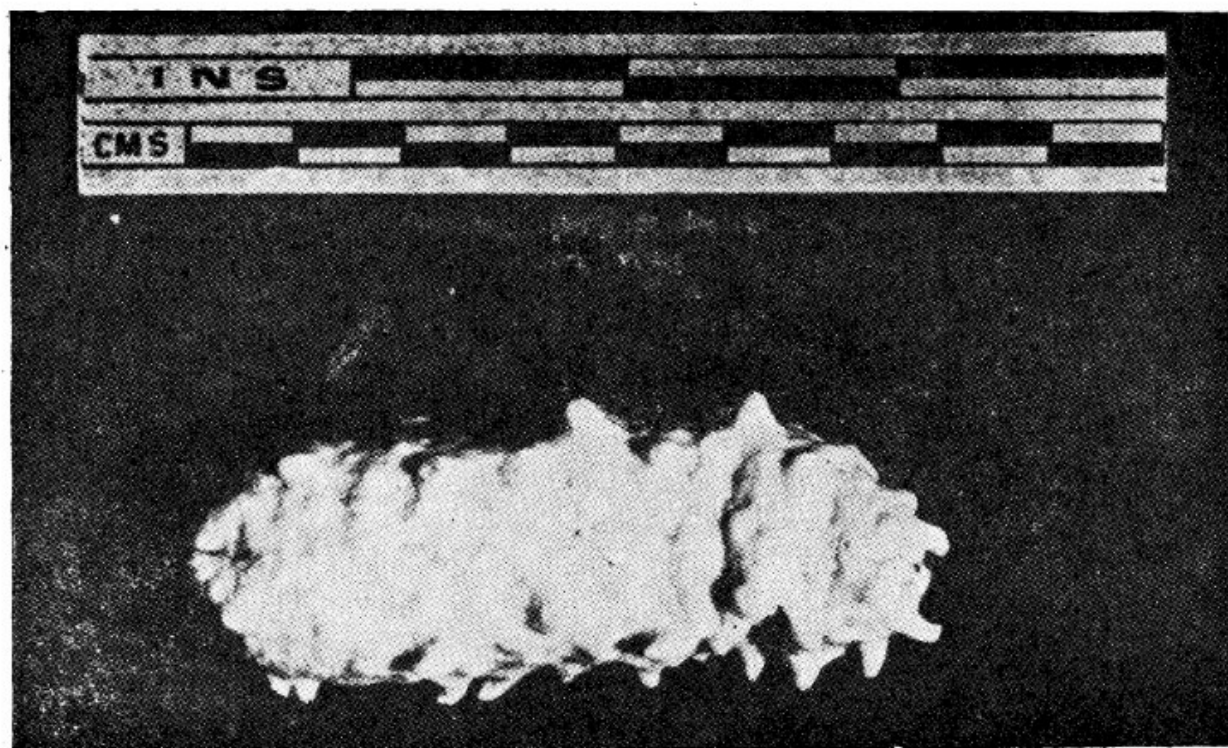


Fig. 9. *Pentacta quadrangularis* (Lesson).

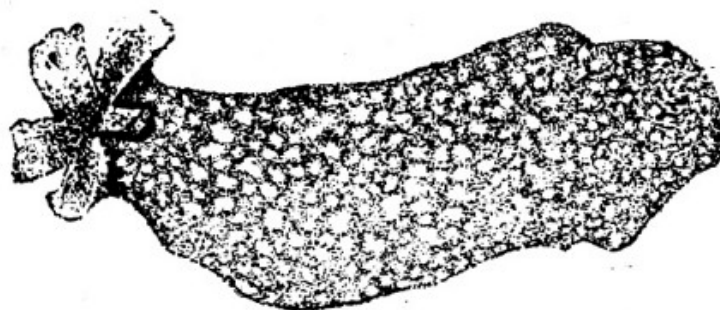



Fig. 10. *Psolus complanatus* Semper. 
($\times 6$).

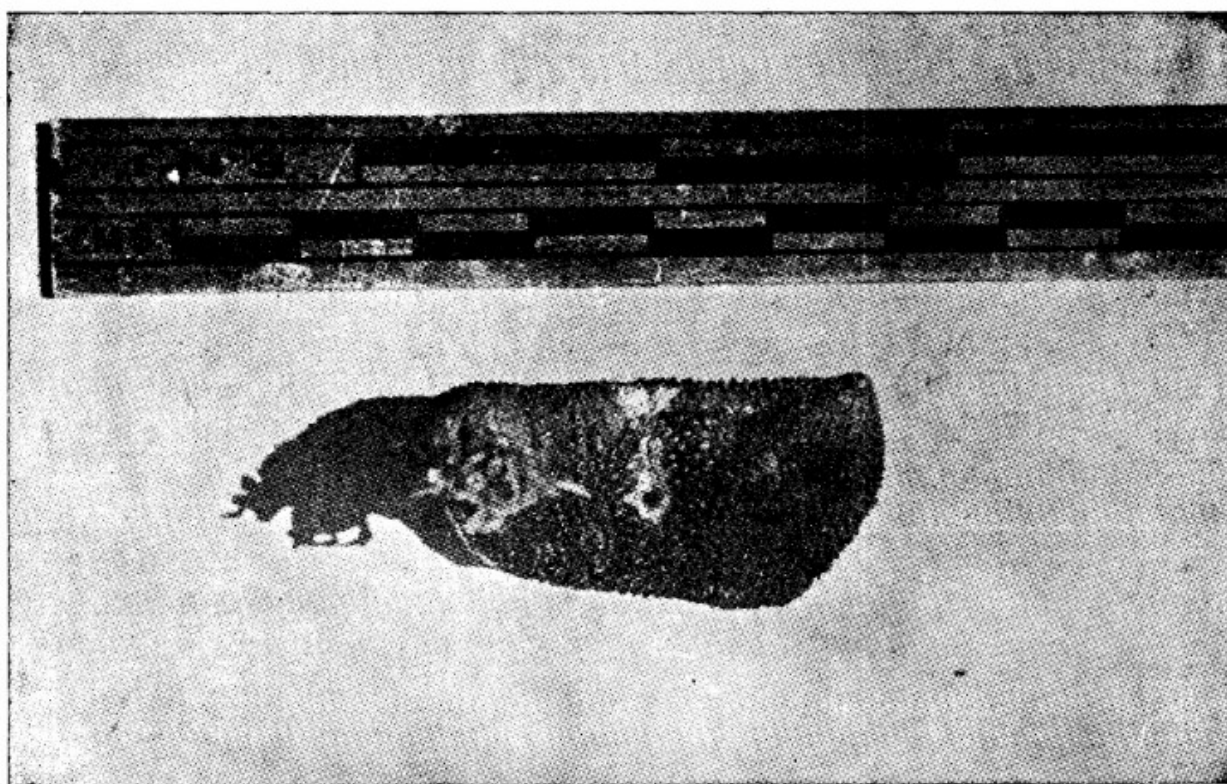


Fig. 11. *Phyllophorus dubia* (Bedford).



Fig. 12. *Holothuria atra* Jäger.

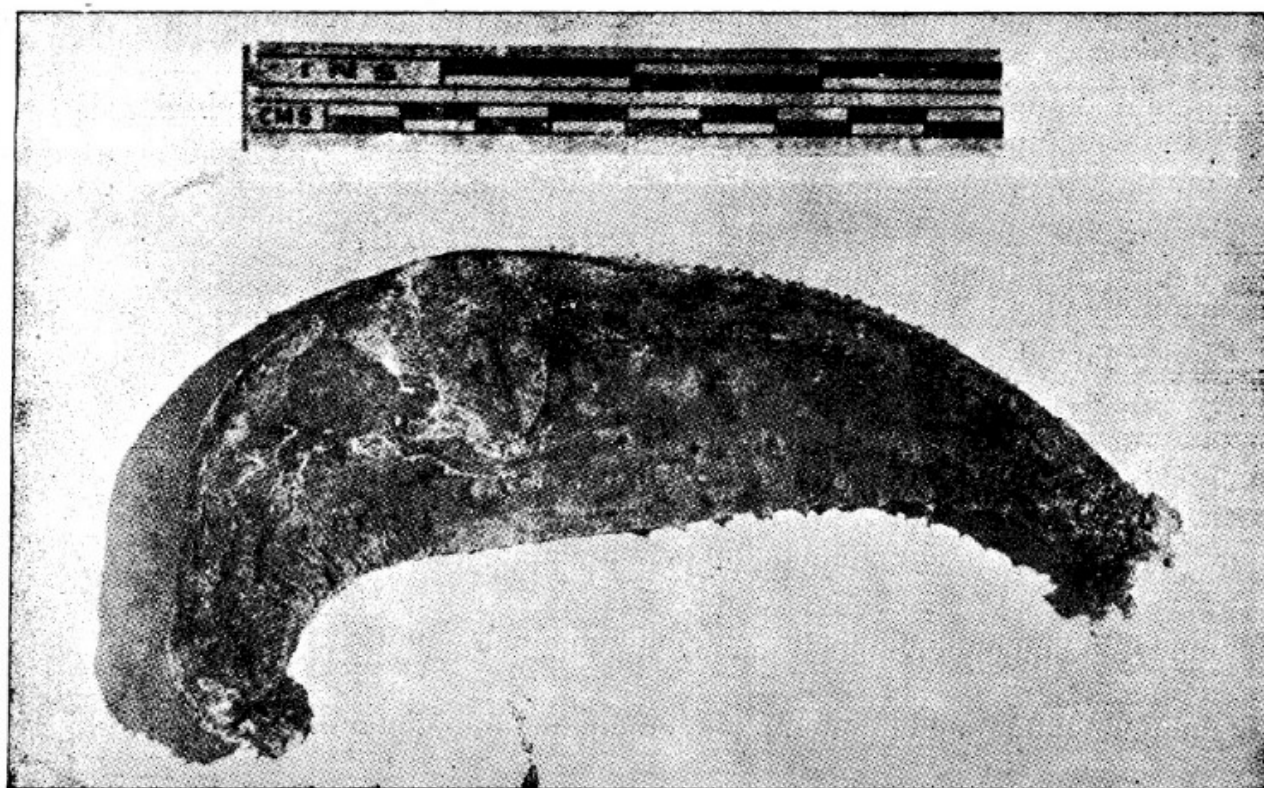


Fig. 13. *Holothuria lubrica* Selenka.

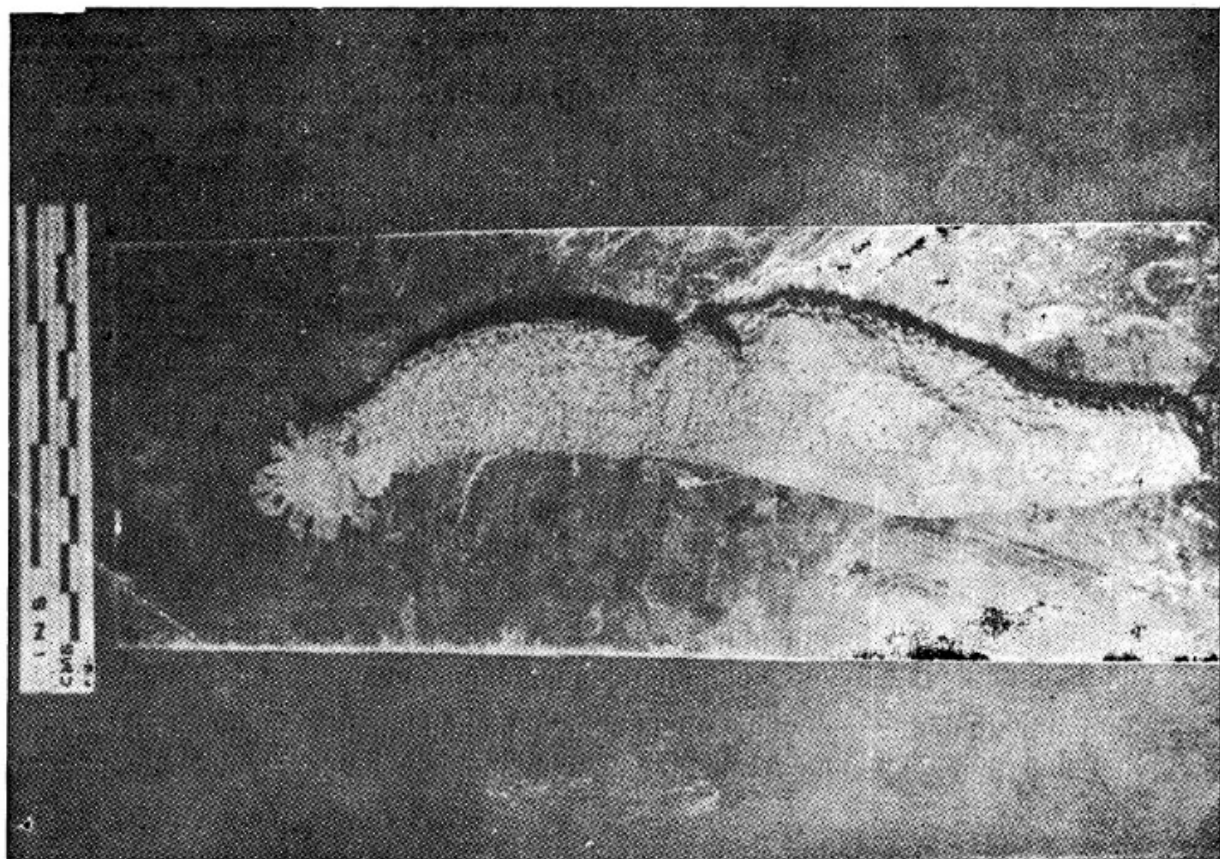


Fig. 14. *Holothuria monacaria* (Lesson).

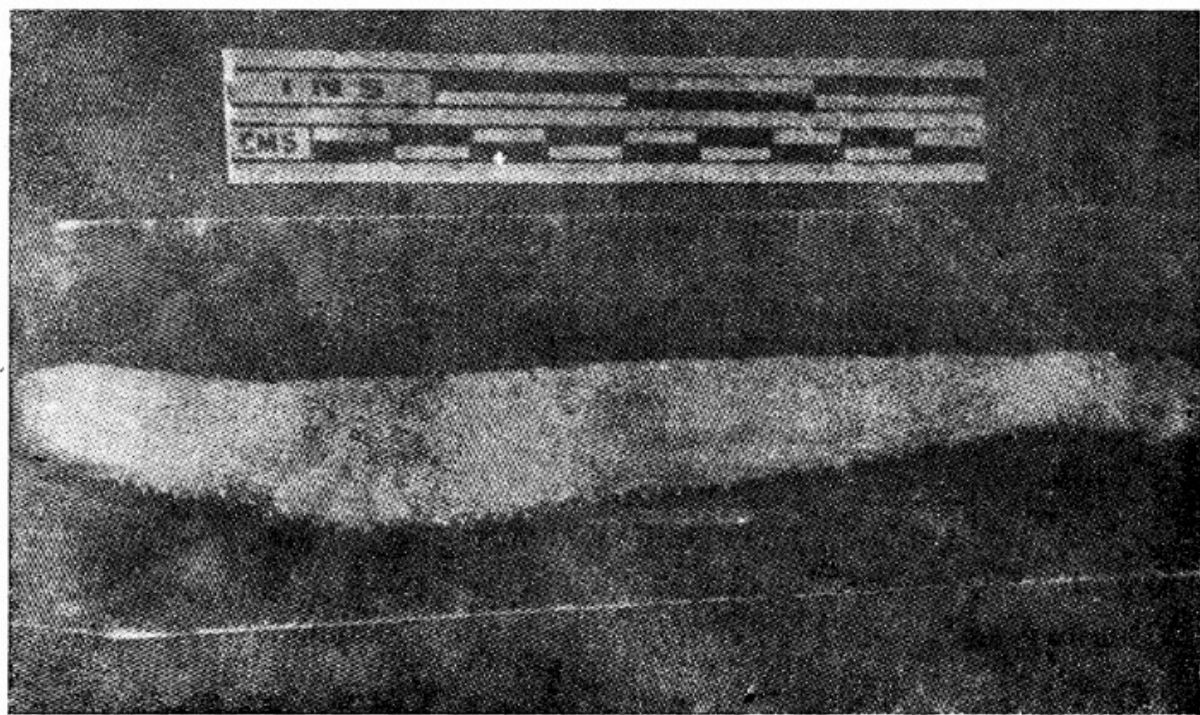


Fig. 15. *Holothuria pardalis* Selenka.

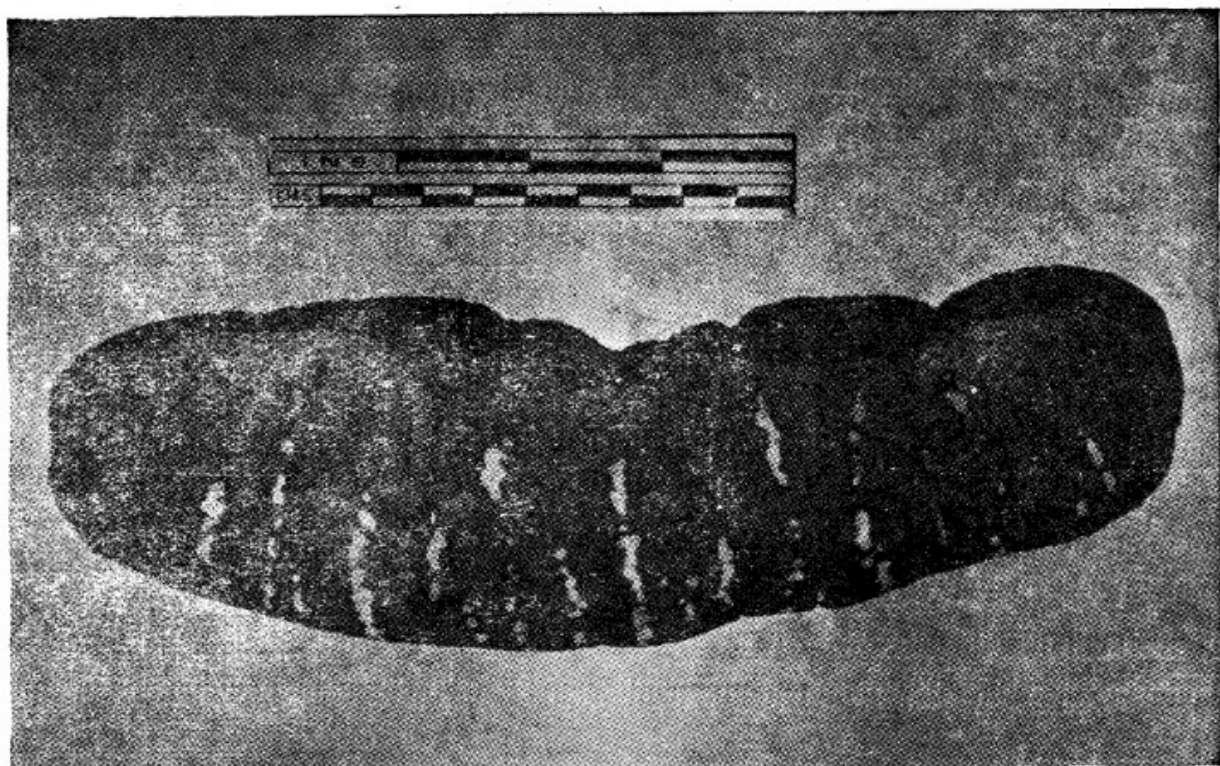


Fig. 16. *Holothuria scabra* Jäger.

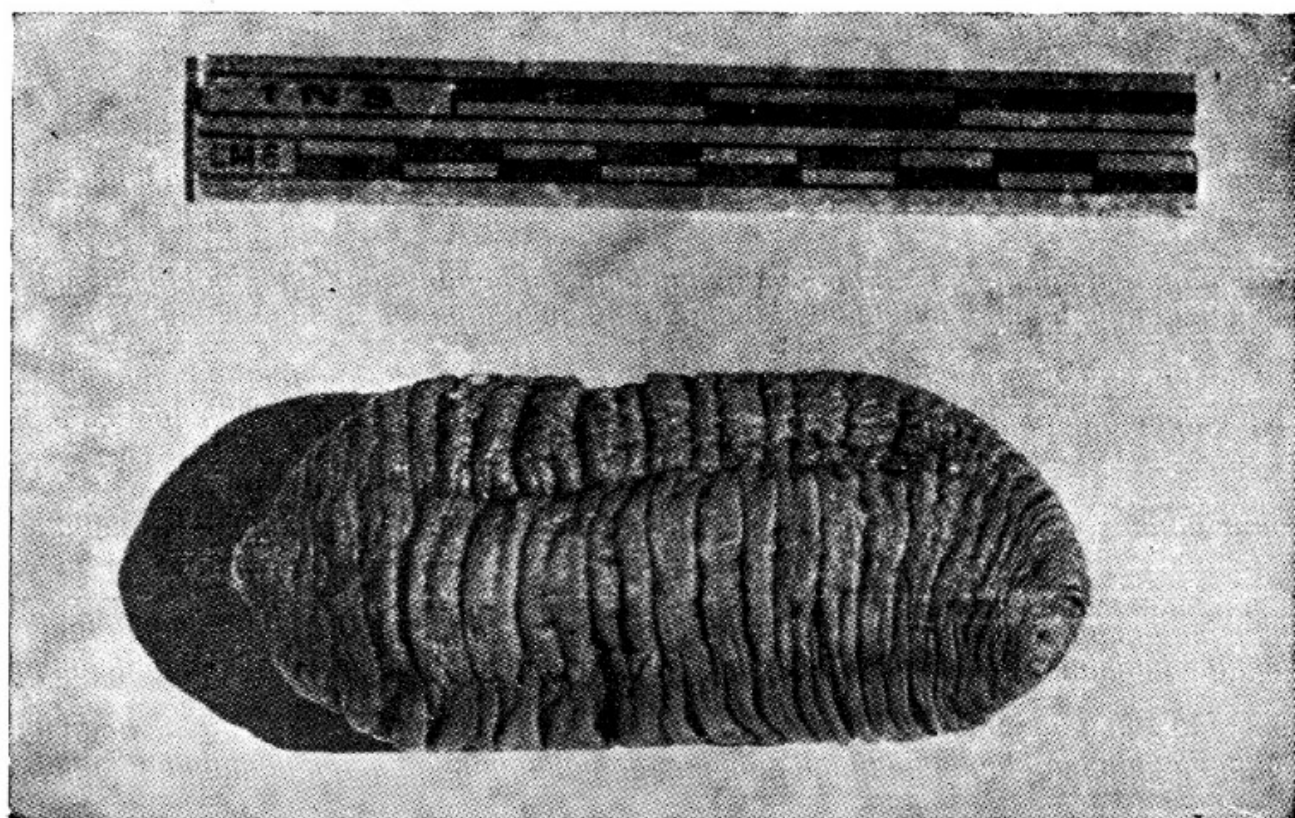


Fig. 17. *Holothuria vagabunda* Selenka.

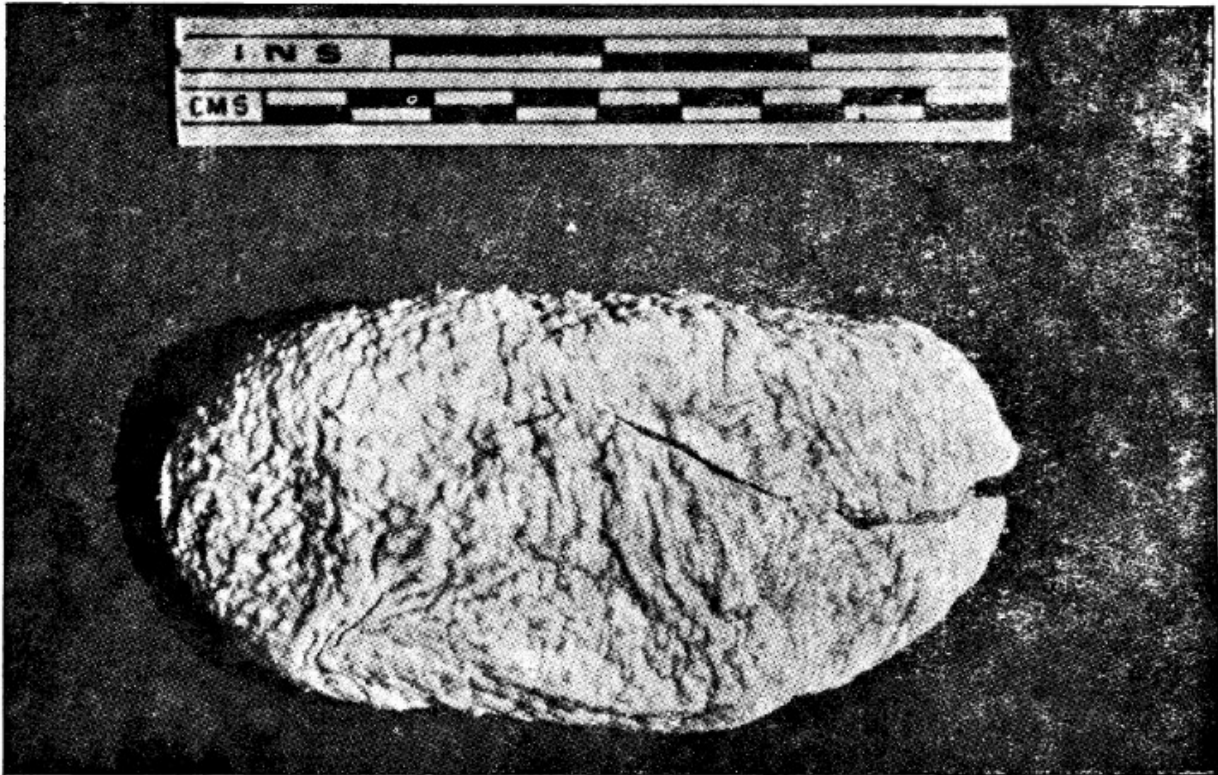


Fig. 18. *Holothuria marmorata* (Jäger).

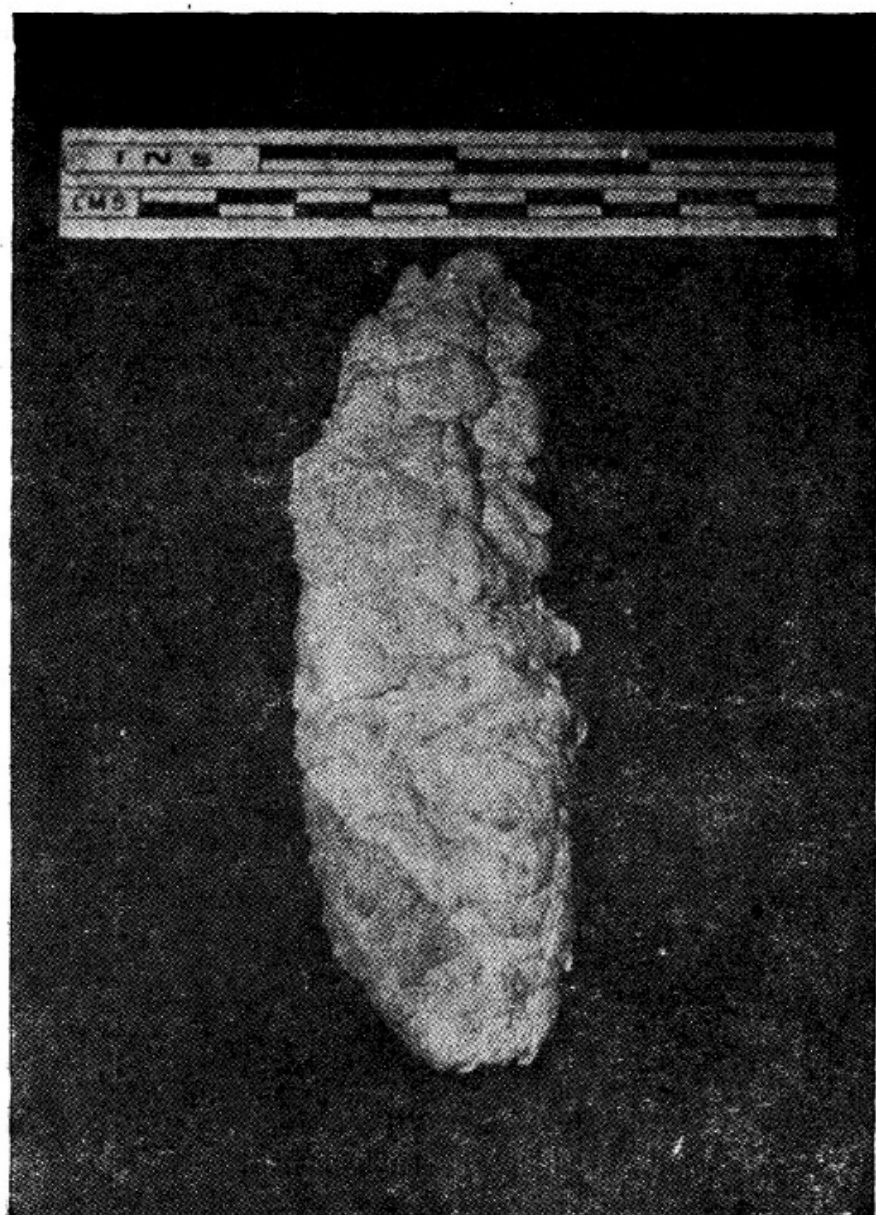


Fig. 19. *Stichopus chloronotus* Brandt.

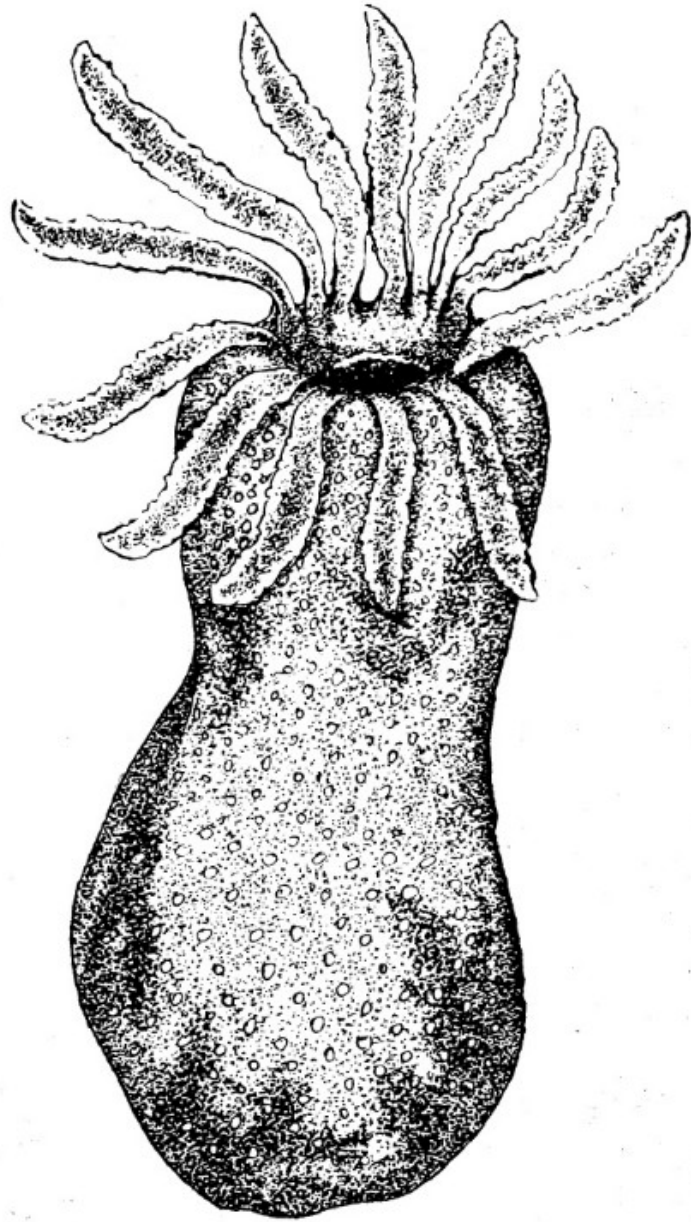


Fig. 20. *Synapta recta* Semper.
($\times 6$).

These specimens were reported as living among sponge branches. The colour, when alive, is described as purplish or striped lilac on a white ground. The five rays of the body are marked by five narrow white bands. The region between these rays is marked with numerous delicate lilac stripes forming a pattern which is variable in different individuals. The tentacles have been observed to be used for progression and are flattened for about two-thirds of their lengths from the apex.

There are thirteen tentacles present, each having nineteen digits. There are about eighteen polian vesicles, six being larger, and the rest smaller. There is one madreporic canal. The alimentary canal is looped.

The deposits in the Ceylon and Pamban specimens of this species seem to agree with Sluiter's figures. Pearson has found, however, that some of the Anchor plates differ from the usual form in having smooth holes. There are also present in the skin numerous miliary granules which are arranged in groups of six or seven, having typically one central granule, surrounded by numerous granules in a circle. Pearson states that this species (*Synapta striata*) appears to be very closely allied to *Synapta recta* and *Synapta indivisa*, but it has since been established that *Synapta striata* is a synonym for *Synapta recta*.

Theél (*loc. cit.*, p. 24), reporting on the "Challenger" specimens of this species, includes this species in the group of Synaptids having thirteen tentacles, and describes the tentacles as bearing very short digits. A cartilaginous ring is present, with holes posteriorly. Theél also reports, in the "Challenger" specimens, nine long and three to four shorter Polian vesicles. A single madreporic canal is also reported to be present in these specimens. The deposits are said to resemble those of *Synapta indivisa* closely. The Anchor arms are smaller, smooth, holes. The miliary granules are described as three large and some smaller, smooth holes. The miliary granules are described as being resette shaped. This species (*Synapta recta*) is especially distinguished by the intestine not forming convolutions.

Semper (*loc. cit.*, p. 14) reporting on the specimens collected from Bohol in the Philippine Archipelago at a depth of 6—8 fathoms, describes this species as possessing thirteen feathery tentacles which have very short stalks. Their side branches appear to be very short and in spirit specimens they are reported to appear as small tubercles. The colour is described as dark violet and finely striped with yellowish white.

Semper remarks that this is the only Philippine species of *Synapta* without a twisted gut. The gut runs a straight course and is attached throughout its length by the dorsal mesenterium. Nine comparatively very long Polian vesicles and three to four smaller ones are also reported to be present in these specimens from the Philippines. The holes (perforations) of the calcareous ring are at the hind margin of the same.

Bedford (*loc. cit.*, p. 142) reports one specimen of this species from off China Straits, New Guinea, 4 centimetres long and with tentacles up to 12 mm. in length; its colour is described as being "speckled" when alive. This specimen is reported to correspond exactly with Semper's original description and figures. In fresh condition thirteen tentacles were counted. The colour pattern is said to consist of alternate light and dark greyish longitudinal bands, thickly speckled with whitish spots.

Recorded localities :—Yard Cave, Trincomalee, Ceylon ; Bohol, Philippine Islands ; Off China Straits, New Guinea ; Pamban, Pamban Bridge and Rameswaram in the Gulf of Manaar, South India.

Specimens in the collection.—There are numerous small, spirit-preserved specimens in the Reference Collection, collected from under the Pamban Bridge, Pamban, in the Gulf of Manaar. The specimens are all fragile, worm-like, with a thin, sac-like body wall.

Some of the specimens are small, pale brownish in colour and are barely more than an inch or an inch and a half in length. These are probably young specimens.

The larger, adult specimens are greyish brown or dull purplish grey in alcohol.

The largest specimen measures 135 mm. in length and 15 mm. in width at the middle of the body. The tentacles are clearly seen in this specimen, although rather badly contracted. The body wall is thin and membranous for the most part, but it is more tough and rigid in the anterior one-third of the length of the body where the body is rather narrow and contracted and the surface is full of transverse wrinkles and furrows. The specimen is dull greyish.

In addition to the above specimens, there are a few similar, but smaller dull purplish grey or blackish grey specimens in the Reference Collection, from Madras, labelled as "*Synapta* sp." but these also appear to belong to the same species, *Synapta recta*.

CLASS ECHINOIDEA

The Echinoida are Echinoderms of globose, ovoid or discoidal shape with a marked, pentamerous or secondarily bilateral symmetry, oriented with the oral surface downward, provided with two to five, mostly five, gonads, and covered with spines borne on an endoskeletal shell or test which is usually rigid and composed of closely fitted calcareous plates arranged in twenty meridional rows (ten ambulacral and ten interambulacral) of which the former are pierced with pores for the passage of the tube feet or podia.

The Echinoids are exclusively marine animals adapted to an existence on the sea bottom. They include the animals commonly known as sea urchins, heart urchins and sand dollars.

The Echinoids are subdivided into two distinct groups or subclasses—the Regular Echinoids (Regularia or Endocyclica) and the Irregular Echinoids (Irregularia or Exocyclica). The former, which comprises the Regular sea urchins, are typically of globose shape and usually more or less flattened at the poles, but some are oval and the anus is situated centrally on the aboral surface. In the Irregular Echinoids, which comprise the Heart urchins, Cake urchins, Sand dollars, etc., the periproct including the anus has moved out of the centre of the aboral surface and most of them show a decided tendency towards a secondary bilateral symmetry.

SUBCLASS REGULARIA (=ENDOCYCLICA)

In this Subclass, which comprises the Regular Echinoids or sea urchins in the strict sense, the test generally has a rounded profile and is pentamerously symmetrical, with regularly alternating ambulacra and interambulacra, the peristome and the periproct occupy central positions at the oral and aboral poles respectively, and the periproct is encircled by the apical system of plates.

ORDER AULODONTA

This and the succeeding Order, the Striodonta under this Subclass include the most typical of the Regular Sea urchins. The coronal plates do not continue on to the peristome where plates of the ambulacral system are represented only by the ten buccal plates. Gills are present. Globiferous pedicellariae are lacking, but the other three types are well represented. The epiphyses in the Aristotle's Lantern are small and do not meet above the tooth, leaving a large, open space in each pyramid and the teeth lack keels. Small auricles are present on the perignathic girdle.

The two species of this Order represented in the Museum collection belong to the family Diadematidae, which is the most important and best known of the Aulodont families, comprising forms which live mostly in the littoral and sub-littoral zones.

Family DIADEMATIDAE

This family is distinguished by the slender, fragile, hollow spines, often very long, armed with whorls of minute teeth. These sea urchins are generally of large size and purple or black in colour, sometimes with spots or streaks of a brilliant blue colour along the aboral ambulacra. In some genera the spines are very long and are reported to be poisonous.

The two species represented in the Museum collection belong to the genera *Astropyga* and *Echinothrix*.

Genus *Astropyga* Gray.

The test is large and flattened and the elongated genital plates render the aboral central part star-like in appearance. A depressed spineless, interambulacral area extends from each genital plate towards the ambitus and this area bifurcates. These naked areas are marked by bright blue spots.

The primary spines are relatively short, rough and almost solid. The actinal surface bears normal primary tubercles. The poriferous areas become wider at the peristome.

The test of *Astropyga* is thin, with the plates loosely connected, so that the whole test is more or less flexible. The test is greatly depressed. The interambulacra are often sunken far below the convex ambulacra near the abactinal pole. The spines rarely attain a length equal to half the diameter of the test. The coronal plates of the actinal surface and near the ambitus are deeply pitted when seen from the inside of the test, the pits corresponding to the primary tubercles.

Only a single species of this genus; *Astropyga radiata*, which is widely distributed in the Indo-Pacific Region, is represented in the Museum collection.

Astropyga radiata (Leske).

FIGURES 21 AND 22.

Cidaris radiata, Leske, 1778, Add. ad Klein, p. 52.

Astropyga radiata, Gray, Ann. Phil., XXVI, 1825, p. 426.

Astropyga mossambica, Peters, 1855, Abhandl., Akad. Berlin, 1854, fig. 1.

Astropyga radiata, Agassiz, A., "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard, No. VII, 1872-74, p. 420; II, pl. xxiv, fig. 40.

Astropyga radiata, Bell, Report on the Echinoderms (other than Holothurians) collected by Dr. Willey, in Willey's Zoological Results, Part II, (Cambridge, 1899), p. 135. (*Astropyga elastica* and *Astropyga radiata*).

Astropyga radiata, Clark, H.L., A Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, 1925, p. 46.

Astropyga radiata, Agassiz, Report of the Scientific Results of the Voyage of "H.M.S. Challenger", Zoology, III, 1880, p. 70; Plate Xa, figs. 8 and 9.

Astropyga radiata, Meijere, Siboga Expeditie, Echinoidea, Livr. XIV, 1904, p. 56.

Astropyga radiata, Duncan, "On the Anatomy of the Ambulacra of the Recent Diadematodea", Journ. Linn. Soc. London, XIX, p. 107.

Astropyga radiata, Koehler, Echinodermes recueillies par M. Korotnev sur les îles de la Sonde, Mem. Soc. Zool. France, 1895, p. 412.

- Astropyga radiata*, Preffer, Ostafrikanische Echiniden, ges von Dr. Stuhlmann, Mittheil, Naturh. Mus. Hamburg, XIII, p. 46.
- Astropyga radiata*, Echinodermen von Ternate (ges von Kukenthal), Abhandl. Senckenb. Naturf. Gesellsch., XXV, p. 83.
- Astropyga radiata*, Döderlein, Bericht ub. die v. Semon ges. Echinoidea, Semon. Zool. Forschungs., V, Jan. Denkschr., VIII, p. 57, (699).
- Astropyga radiata*, Hyman, The Invertebrata, Echinodermata, 1955, p. 521.

This is a widely distributed species in the Indo-Pacific Region and has been recorded both from the Pacific and Indian Oceans. The test is strongly flattened. The peristome is small, somewhat depressed, and with moderately deep, broad, actinal slits. The peristomial membrane is strengthened by closely packed rectangular or irregularly elliptical plates. The entire actinal part of the test is covered by tubercles of uniform size, forming closely arranged vertical and transverse rows. The columns of primary tubercles on the actinal surface are parallel with the margin of the ambulacrum.

The outline of the test as seen from above is pentagonal. There are two rows of primary tubercles, extending to the ambitus, of uniform size, somewhat smaller than the primary rows of the interambulacra. The whole abactinal part of the test is flat. The proiferous zone is broadest, about two-thirds the distance from the ambitus to the abactinal system, tapering rapidly to the apex, but growing very gradually narrower from the ambitus on the actinal surface, being very slightly petaloid near the peristome.

In the interambulacral spaces, the whole of the abactinal part of the test is occupied by the broad, bare, forking band, separated from the proiferous zone by one principal vertical row of secondaries extending to the abactinal system, this primary row being flanked interiorly, near the abactinal system by a short, parallel row of secondaries, and by an interior row of small tubercles near the ambitus.

The coronal plates are narrow and elongate. The tubercles of both ambulacral and interambulacral areas are small, very distinctly crenulated with a broad, flat, scrobicular circle, sharply marked, and slightly raised above the general level of the test. The spines are extremely slender and short, compared to the great diameter of the test in the other species of this family. They are either uniformly coloured or variegated by transverse bands of a lighter colour. The abactinal system (i.e., the apical system) is large; the anal plates are elongate and triangular. The madreporic genital plate is slightly larger than the others. The genital openings are close to the apex, separated by narrow, rectangular, ocular plates adjoining the large, anal area.

In young specimens, the ambulacra are quite swollen near the edge and the outline is more or less pentagonal. The actinal part of the test is not so strongly flattened, nor is it thickly covered by tubercles as in adult specimens. The actinostome (peristome) is very large in proportion to the diameter of the test. The proiferous zone is of uniform width, the tubercles being proportionately much larger. The pits extending along the sides of the bare, median interambulacral space are well marked.

The columns of primary tubercles on the actinal surface are parallel with the margin of the ambulacrum.

The colour of this species, when alive, is subject to considerable variation. Typically, the colour is whitish green, mixed with reddish brown. The anal system, genital plates and the bare median interambulacra are reddish, with a row of sky-blue spots placed in the pits of the coronal plates. Numerous similar spots are also found on the actinal membrane. The spines are reddish brown, ringed with greenish white. The dried specimens vary from a nearly uniform, greenish white test, to a uniform dirty violet colour.

Specimens of this species from the Hawaiian Island show a very striking colouration, being reddish white and red, much brighter and more showy than in the specimens from the Indian Ocean. A specimen from the Andamans reported by Clark, (*loc. cit.*, p. 46) is reported to have the test of a deep red colour typical of *Astropyga radiata*, but the specimens are banded with pale green and red. Specimens from the eastern coast of Africa are said to be usually quite dark. A specimen from Mauritius reported by Clark (*loc. cit.*, p. 46) is said to be greenish yellow, with no indication of red. Clark (*loc. cit.*, p. 46) also reports that a specimen from Seychelles taken by the Alert Expedition is the largest in the British Museum collection and is said to measure 165 mm. in diameter.

Meijere (*loc. cit.*, p. 56) reports that among the specimens of this species from the Siboga Expedition Collection, examined by him, not even a single one was a full grown specimen. All of them are reported to be rather very small ranging from 10 to 20 mm. in diameter. The rows of primary tubercles in these specimens are said to proceed up to the peristome. They diminish gradually in size and the secondary tubercles found between them are very scanty. The peristome is reported to be proportionately large in comparison with the diameter of the test in these young specimens. The peristome of a specimen 21 mm. broad is cited as being 9 mm. in diameter, and the peristome of another specimen (from Banda) 16 mm. in diameter is cited as being 7 mm. in diameter. The colouration of these specimens is also reported to be variable. In the specimen from Banda, reported by Meijere (*loc. cit.*, p. 56), the middle interambulacral area (on the apical side) which is demarcated by the eye spots is white while the other parts are red.

This species has also been recorded from the Loyalty Islands (Bell, *loc. cit.*, p. 135). Bell reports that this is a more westerly locality than has as yet been recorded for this species.

Specimens in the collection.—Two specimens preserved in alcohol. Locality: From off Nagapattinam.

The specimens are rather large, with whitish tests and purplish, or purplish white spines, most of which have fallen off from the tests. The spines are long and slender, and many of them are purplish with white tips. The test is large, rather flattened. The actinal surface (i.e., the oral surface) is flat. The peristome is placed in a deeply depressed (concavely sunken) area in the centre of the actinal surface. On the abactinal side, the ambulacral areas are rather raised and separated by the somewhat depressed interambulacral spaces, which are occupied by the bare, broad, forking bands. On the actinal side, the jaws of the lantern are seen clearly protruding from the mouth as a conical structure. The primary tubercles, disposed in rows, all over the test both on the ambulacral and interambulacral areas are white, distinctly crenulated, with a broad, flat, sharply marked, scrobicular circle, slightly raised above the general level of the test.

As the spines have mostly dropped off from the actinal surface in the present specimens, the spines appear more numerous and close-set on the abactinal surface in the present specimens.

This is one of the largest of the regular sea urchins inhabiting the coastal waters on the East Coast of Peninsular India, but appears to be rather rare.

Measurements: Diameter of the test at the ambitus: 118 mm.

Height of the test: 49 mm.

The average length of a primary spine is about 26 mm.

Both specimens measure more or less the same dimensions.

Genus *Echinothrix* Peters.

This genus is somewhat intermediate between *Diadema* and *Astropyga* in its characters. The test is firm, flattened and moderately stout. There are larger tubercles instead of the larger tubercles of uniform size typical of *Astropyga*. The ambulacra differ from those of *Astropyga* in having many vertical rows of very small tubercles instead of the larger tubercles of uniform size typical of *Astropyga*. The ambulacra are also much broader near the abactinal system where they become petaloid. The poriferous zone is broad and the pores are arranged as in *Astropyga*. Large spines are confined to the broad interambulacra, and the narrow ambulacra bear only five spines, elongated aborally and capable of inflicting severe wounds. The spines of the sea urchins of this genus are often beautifully banded. At first sight the spines of the two areas appear quite different, but the difference is only in their size — those of the narrow ambulacra being fine, elongated, silk-like spines, while those of the broad interambulacra are large, verticillate or longitudinally striated. But they are not as hollow as in *Diadema*. The anal system is strongly protected at the base by plates, as in *Astropyga*.

The primary spines are rough and hollow. There are no spines on the buccal plates. The ambulacra bear numerous secondaries above the ambitus and are wider abactinally than in the mid zone.

The abactinal system resembles that of *Astropyga*, but the plates are not quite so elongate. There is no bare, forked median interambulacral space as in *Astropyga*.

Two species of this genus, namely, *Echinothrix calamaris* and *Echinothrix diadema* are common and are widely distributed in the Indo-West Pacific Region.

Of these, only one species, *Echinothrix calamaris*, is represented in the Museum collection by a specimen collected from Tuticorin.

Echinothrix calamaris (Pallas).

FIGURE 23

Echinus calamaris, Pallas, Spic. Zool. I, fasc. 1774, 10, p. 31.

Echinothrix calamaris, Agassiz, A., "Revision of the Echini" Cat. Mus. Comp. Zool., Harvard, No. VII, 1872-74, pt. 1, 1872; pb. 119-120.

Echinothrix calamaris, Agassiz, A., "Revision of the Echini" Cat. Mus. Comp. Zool., Harvard, No. VIII, 1872-74, pt. III, p. 413; pl. III a. figs. 1-2; pl. XXXV, figs. 10-15.

Echinothrix calamaris, Agassiz, Report of the Scientific Results of the Voyage of "H.M.S. Challenger", Zoology, III, 1880, p. 67.

Echinothrix calamaris, Th. Studer, "Gazelle", Echiniden, Monasth. Ak Wissensch., Berlin, 1880, p. 868.

Echinothrix calamaris, Tenison Woods, "On the habits of some Australian Echini", Proc. Linn. Soc New South Wales, V, p. 195.

Echinothrix calamaris, Duncan and Sladen, "On the Anatomy of the Ambulacra of the Recent dematiidae", Journ. Linn. London, Zoology, XIX, p. Desori) and p. 106.

Echinothrix calamaris, Duncan, "On the perignathic girdle of Echinoidea", Journ. Linn. Soc London, Zoology, XIX, p. 202 Desori).

Echinothrix calamaris, Loven, "The Linnaean species of Echinoidea" Bin. Kgl. Svensk. Vet. Ak. Handl., III, 4, 1887, p. 137. E. *Diadema*).

- Echinothrix calamaris*, Von Martens, Echinodermen aus Neu-Guinea Sitzungsber. Ges. Nat. Fr. Berlin, 1889, p. 184
- Echinothrix calamaris*, Koehler, "Echinodermes des îles de la Sonde", Mem. Soc. Zool. France, 1895, p. 411, (*E. Desori*).
- Echinothrix calamaris*, Sluiter, Die Echiniden, Sammlung des Museums zu Amsterdam, Bijdragen tot de ., Dierg XVII, 1894, p. 68..
- Echinothrix calamaris*, Ludwig, Echinodermen des Sansibar-gebietes, ges. v. VOELTZKOW, Abhand. Senck. naturf. Gesellsch., XXI p. 5531 (*E. Desori*).
- Echinothrix calamaris*, Pfeffer, Echinodermen von Ternate Abh. Senckenb. naturf. Gesellsch., XXV p. 83.
- Echinothrix calamaris*, Whitelegge, The Echinodermata of Funafuti, Austr. Mus., III Atoll Funafuti, p. 2, p. 156.
- Echinothrix calamaris*, Doderlein, Bericht ub. die von gesamm. Echinoidea in Semon's Zoo. Forschungs. V. Jan Denkschr., VIII, Mem. 1902, p. 56 (698).
- Echinothrix calamaris*, Anderson, Rep. Mar. Survey of India. 1898—1899, p. 13.
- Echinothrix calamaris*, Bell, Fauna and Geography of the Maldives and Laccadive Archipelagoes, p. 230. (*E. Desori*).
- Echinothrix calamaris*, Meijere, Siboga-Expeditie, Echinoidea, Livr. XIV, 1904, p. 51.
- Echinothrix calamaris*, Clark, H.L., "Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, 1925, p. 44.
- Echinothrix calamaris*, Clark, A.H., "Echinoderms from the Marshall Islands", Proc. United States National Museum, Vol. 102, 1952, p. 269.
- Echinothrix calamaris*, Hyman, The Invertebrates, Echinodermata, 1955, p. 522.

This species is closely related to *Echinothrix Desori* and Meijere (*loc. cit.*, p. 51) is of the opinion that the two are synonymous. The interambulacral primary spines are fragile, the inner cavity being more than half the diameter of the spine. Minute teeth are present, covering the surface of the spines and arranged in distinctly separated whorls. The larger spines are usually black and white, while the ambulacral ones are yellowish green. But in old specimens, the spines tend to become dull and black and lose their distinctive appearance. The spines of the young specimens of this species are comparatively shorter, but at the same time also proportionately much broader, more or less spreading at the extremity, hollow throughout their entire length, and extremely thin and delicate. The spines of older specimens frequently retain these characteristics of the young until they attain quite a large size. Generally, with increasing age, the spines become comparatively more tapering and stouter. In the interambulacral region, the bare median space extends nearly to the ambitus.

There are only four primary tubercles on each coronal plate, few secondaries and numerous prominent miliaries. The peristomial membrane is closely covered by large, calcareous plates. The ambulacra are broad and the poriferous zone is of moderate width, with from three to four median rows of secondary tubercles between the two outer ones. The ambulacra near the abactinal system is slightly raised, so that the test is slightly inflated near the ambitus, with flattened actinal surface and somewhat conical outline towards the abactinal pole, with depressed, abactinal area. The abactinal system is remarkable for the large size of the anal system, covered by a thin

membrane, and only strengthened by a few calcareous granules, a single row of plates near the genital ring, and the small size of the equilaterally triangular genital plates, separated by greatly elongated ocular plates.

The colour of the spines varies from a uniform straw colour to a light violet colour, with four or five broad bands of a darker colour, the test and the ambulacral spines being generally of a darker tint. The colouration of the tubercles is quite indistinct.

The peristomial membrane as well as the anal membrane of the young is thickly covered by plates. The profile of small specimens is also more nearly globular.

Large adult specimens of this species from Mauritius in the British Museum collection are said to be dull and dark-coloured, being very different from the typical specimens from other localities. There is considerable variation in the colour and appearance of specimens of this species from different localities.

Specimens in the collection: One specimen, wet-preserved in alcohol. *Locality:* Thalayirampar, Tuticorin.

The test is rather flat, firm and moderately thick. The spines are stout, longish and tapering towards the tip, and beautifully cross-banded alternately with black and white. The abactinal wall of the test, unfortunately, is broken in the present specimen. The test and the ambulacral spines are of a darker colour than the spines in the interambulacral area. The surface of the spines is finely and closely serrated. The primary tubercles are large, white, with raised scrobicular circle round the base which is distinctly striated (milled). The actinal surface is flattened and the abactinal area is depressed. There are few secondary tubercles, but numerous prominent miliary tubercles are present.

Measurements: Length of an average primary spine: 44 mm.

Diameter of the test: 83 mm.

Height of the test: 33 mm.

ORDER STRIODONTA

The Striodonta include mostly extinct species of regular sea urchins and consist of four wholly extinct families, two other families, each represented by only one living species, and two other families, the Salenidae and Arbaciidae which contain a number of living genera and species.

In this Order, as in the Aulodonta, the epiphysis of the lantern are small, and do not unite above the teeth, but the teeth are keeled. The pergnathic girdle gives rise to auricles in the radial positions and is reduced to a ridge or wall in the inter-radii. The spines are solid, with or without a cortex, and globiferous pedicellariae are generally absent.

Only a single family, the Stomopneustidae, is represented in the Museum collection by the single species, *Stomopneustes variolaris*, which is the only living species of the family.

Family STOMOPNEUSTIDAE

This family is characterized by the presence of a periproct of small plates, and is represented by only one living species, namely, *Stomopneustes variolaris*, which is represented in the Museum collection by several specimens from the Madras Coast and from the Gulf of Manaar area.

The teeth are keeled. The primary tubercles are imperforate. The ambulacral plates are compound, composed of three elements, but in the median zone, every four or five such plates are united and overgrown by one large primary tubercle.

As mentioned above, this family includes only a single living genus and species, namely, *Stomopneustes variolaris*, a rather large, black or blackish violet sea urchin with polyporous ambulacral plates. It is a widely distributed species and is common in the littoral zone in shallow waters in the Indo-Pacific Region.

Genus *Stomopneustes* Agassiz.

The test is large, stout and nearly circular, although there is a slight tendency towards obliquity in the axis of old specimens. The primary spines are long, stout and finely longitudinally striated. The actinal surface is flat, the poriferous zones becoming petaloid; while above the ambitus, it is narrow, forming three irregular vertical lines of parallel rows of pores. The peristome is small, the actinal slits being scarcely marked. The primary tubercles are conspicuous. There are only two principal rows of primary tubercles, both in the ambulacral and interambulacral areas.

The single living species of this genus, namely, *Stomopneustes variolaris*, is represented in the Museum collection by several specimens, both dry and wet-preserved. It is one of the commonest and most familiar species of regular sea urchins found in the littoral zones around the South Indian shores.

Stomopneustes variolaris (Lamarck).

FIGURES 24, 25 and 26.

- Echinus variolaris*, Lamarck, Histoire naturelle des Animaux sans Vertèbr. 1816, III, p. 47.
- Stomopneustes variolaris*, Agassiz, Mem. Ech. Anat., Echinus, 1841, p. x.
- Stomopneustes variolaris*, Agassiz, "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard, No. VII, 1872-74, pt. III, p. 437, pl. iv, figs. 1-3, pl. xxiv, figs. 31-32; pl. vi, figs. 11-11a; pl. xxxvi, figs. 2, 3.
- Stomopneustes variolaris*, Tenison Woods, "The Echini of Australia", Proc. Linn. Soc., New South Wales, II, 1878, p. 156.
- Stomopneustes variolaris*, Tenison Woods, "On some New Australian Echini" Ibid., IV, 1880, p. 288.
- Stomopneustes variolaris*, Revision of the Fossil Echini from the Tertiary Strata of Java. Notes, Leyden Museum, II, p. 73.
- Stomopneustes variolaris*, Stewart, "On some structural features of Echinostrephus molaris, etc.", Journ. Micr. Soc., III, 1880, p. 909.
- Stomopneustes variolaris*, Bell, "Observations on the Characters of Echinoidea", IV, The Echinometridae, Proc. Zool. Soc., London, 1881, p. 425.
- Stomopneustes variolaris*, de Loriol, Echinodermes recueillies par M. V. de Robillard à l'île Maurice. Mem. Soc. de Phys. et d'hist. nat. de Geneva, XXVIII, 1883, No. 8, p. 32.
- Stomopneustes variolaris*, Walter, Ceylon's Echinodermen, Jenaische Zeitschr., f. Naturw., XVIII, p. 374.
- Stomopneustes variolaris*, Döderlein, Echinodermen von Ceylon, Zool. Jahrb. Abth. f. Syst., III, 1888, p. 835.
- Stomopneustes variolaris*, Bell, "Report on a Collection of Echinoderms made at Tuticorin, Madras", Proc. Zool. Soc. London, 1888, p. 382.

- Stomopneustes variolaris*, von Martens, Echinodermen aus Neu-Guinea, Sitzb. Ges. naturf. Freunde, Berlin, 1882, No. 9, p. 188.
- Stomopneustes variolaris*, Pfeffer, Ostafrikanische Echiniden, Ges von Stuhlmann, Mittheil. naturh., Mus. Hamburg, XIII, p. 46.
- Stomopneustes variolaris*, Sluiter, Die Echiniden Sammlung des Museums zu Amsterdam, Bijdragen tot de Dierkunde, XVII, 1895, p. 69.
- Stomopneustes variolaris*, Ludwig, Echinodermen des Sansibargbietes (ges von Voeltzkow), Abhandl. Senckenb. naturf. Gesellsch., XXI, p. 554.
- Stomopneustes variolaris*, Anderson, "On some Indian Echinoidea", Journ. Asiatic Soc. Bengal, LXVIII, p. 188.
- Stomopneustes variolaris*, Mortensen, Ingolf-Echinoidea, I, p. 126.
- Stomopneustes variolaris*, Meijere, Siboga-Expeditie, Echinoidea, Livr., XIV, 1904, p. 87.
- Stomopneustes variolaris*, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea), in the British Museum, 1925, p. 68.
- Stomopneustes variolaris*, Gravely, "Littoral Fauna of Krusadai Island, in the Gulf of Manaar", Bull. Mad. Govt. Mus., I, No. 1 (Natural History), 1927.
- Stomopneustes variolaris*, Hyman, The Invertebrates, IV. Echinodermata, 1935, p. 524.

This species is widely distributed in the Indo-Pacific Region and is common in shallow waters in the littoral zone. It has been taken both at Tuticorin and at Krusadai, Pamban and Shingle Islands in the Gulf of Manaar area. It is a rather large, black or violet urchin with polyporous ambulacral plates. A good series of specimens of this species is reported as being represented in the British Museum collection, and H.L. Clark (*loc. cit.*, p. 68), states that the largest of that series is from Tuticorin in South India and measures 95 mm. in diameter and 50 mm. in height. The specimens also exhibit considerable variation in the character and length of their primary spines. Some specimens have shorter and stouter spines, while others have longer and more slender spines. The colour also varies, but is usually very dark, greenish black or purplish black, or very nearly black.

This species has a practically rounded, sub-spherical test, with broad, ambulacral areas and dark, purplish brown spines, much longer on one side of the shell, than on the other.

The test is thick, more or less irregular in outline when seen from above, according to the greater or lesser eccentricity of the axis; the auricles are very slender, somewhat depressed. The abactinal system (apical system of plates) is considerably large, compact and thickly covered with small plates, bearing secondary tubercles. The genital and ocular plates each carry one secondary and several small miliaries. The madreporic genital plate is large, and the genital ring is narrow, with plates of uniform size.

The bare test, with the spines removed, is purplish when fresh, but when bleached, it becomes perfectly chalky white. The test is characterized by the presence of a continuous groove extending along the vertical suture of the plates in the median interambulacral space. This groove is well marked in the ambulacral region. The coronal plates are high. Two principal vertical rows of primary tubercles are present in the ambulacral and interambulacral spaces, the ambulacral space being but slightly smaller than the interambulacral. The ambulacral plates are loosely covered by large secondaries and irregularly arranged miliaries, extending into the poriferous zone. The poriferous zone

is separated from the primary rows of tubercles by a vertical row of small tubercles. Two median interambulacral vertical rows of small tubercles, irregularly arranged separate the primary rows above the median space.

The peristome is small, and the branchial notches (gill cuts) are moderately well marked. The tubercles of the actinal surface are small, but rapidly increase in size towards the ambitus. The principal (i.e., primary) spines are stout, solid, tapering and coarsely striated longitudinally from the prominent milled ring.

As already stated, there is considerable variation in the colour of the specimens. Typically, the colour of the spines in specimens of this species from Mauritius, Java, Samoa, etc., is reported to be olive green, with purplish tips, but the colour of the spines in Indian specimens is normally very dark, greenish black, or purplish black.

The poriferous zone is narrow above the ambitus. It is proportionately narrower in older specimens, where, owing to the great flattening of the actinal surface, the poriferous zone becomes extremely petaloid, but the number of pores in each arc is not increased.

In young specimens, the actinal part of the poriferous zone is only slightly petaloid, the arrangement of the pores above and below the ambitus differing only slightly.

Although this is one of the most characteristic and well defined species of regular Echinoids, yet there is considerable variation in the colour and in the character and length of the spines. Generally, specimens in exposed situations have shorter and stouter spines than those from relatively sheltered localities which tend to have longer and relatively more slender spines.

Numerous "ophiocephalous" type of pedicellariæ are present.

The cleaned and bleached test of this species is commonly sold as a marine curio, and the stiff, stout, blackish spines are sometimes used as slate pencils. The tubercles on the test, on which the spines are mounted, are large and conspicuous.

Specimens in the collection:—

I. Reference Collection: There are three adult, wet-preserved specimens and one very tiny, wet-preserved young specimen besides many dry-preserved tests in the Reference Collection.

(i) One test. (white), without spines.

Locality: Rameswaram, Shingle Island, Gulf of Manaar.

The poriferous zones of the ambulacra and the rows of primary, secondary and miliary tubercles are clearly seen. The edge of the peristomial opening on the oral side is uneven.

Measurements: Diameter of the test: 90 mm.

Height of the test: 45 mm.

Diameter of the peristome: 20 mm.

(ii) One moderate-sized specimen with the purplish black spines intact. The spines are strong, stout and tapering towards the tip, but most of them are blunt at the tip. The spines at the sides of the test are the largest. The spines on the abactinal side are much shorter and point downwards and outwards. The miliary spines are slender. The test is purplish brown, with the tubercles whitish. The pale brownish podia are densely crowded and are most conspicuously seen on the actinal side in the ambulacral areas. Locality: Madras Harbour.

Measurements. Diameter of the test: 66 mm.

Height of test: 38 mm.

Diameter of the peristome: 14 mm.

(iii) A similar, but larger specimen, with more longish, tapering and more sharply pointed spines.

Locality: Harbour Arm, Royapuram Bay, Madras, Chingleput District.

The spines are purplish black. Some of the longer primary spines are longer than 40 mm.

Measurements: Diameter of the test: 70 mm.

Height of the test: 45 mm.

Diameter of the peristome: 16 mm.

(iv) One very small, wet-preserved, young specimen with the spines intact.

Locality: Rameswaram, Shingle Island, Gulf of Manaar.

The specimen is rather pale purplish brown, with the spines short, purplish, somewhat tapering towards the tip and whitish towards the tips.

Measurements: Diameter of the test: 15 mm.

Height of the test: 8 mm.

Diameter of the peristome: 3 mm.

The spines on the abactinal side in this specimen are rather shorter and fewer than those on the oral surface and directed sideways.

Besides the above, a graded series of eight dry-preserved tests of this species, well bleached and white, ranging from a tiny young specimen to a very large, full-grown one from Pulli Island and Shingle Island in the Gulf of Manaar, collected in 1943 are also available in the Reference collections. These are dry, empty shells which were washed up on the beach on these Islands. Portions of the lantern, consisting of the arched calcareous pieces rising from the actinal wall interiorly are persistent in most of these dead tests.

(v) One very young, small specimen, Locality: Pulli Island, Gulf of Manaar.

Measurements: Diameter of the test: 35 mm.

Height of the test: 18 mm.

Diameter of the peristome: 12 mm.

(vi) One slightly larger specimen. Locality: Pulli Island, Gulf of Manaar.

Measurements: Diameter of the test: 56 mm.

Height of the test: 32 mm.

Diameter of the peristome: 13 mm.

(vii) One larger (medium-sized) specimen. Locality: Pulli Island, Gulf of Manaar.

Measurements: Diameter of the test: 78 mm.

Height of the test: 45 mm.

Height of the test: 45 mm.

(viii) One slightly larger (medium-sized) specimen. Locality: Pulli Island, Gulf of Manaar.

Measurements: Diameter of the test: 82 mm.

Height of the test: 50 mm.

Diameter of the peristome: 22 mm.

(ix) One specimen, almost similar in size to the above (specimen No. viii).
Locality: Shingle Island, Gulf of Manaar.

Measurements: Diameter of the test: 63 mm.
 Height of the test: 49 mm.
 Diameter of the peristome
 (which is slightly broken): 24 mm.

(x) One larger specimen. **Locality:** Shingle Island, Gulf of Manaar.

Measurements: Diameter of the test: 92 mm.
 Height of the test: 53 mm.
 Diameter of the peristome: 25 mm.

(xi) One large-sized specimen, not well bleached, and pale dirty brown in colour.
Locality: Shingle Island, Gulf of Manaar.

The apical system of plates is well seen in this specimen.

Measurements: Diameter of the test: 97 mm.
 Height of the test: 58 mm.
 Diameter of the peristome: 25 mm.

(xii) One still larger specimen. **Locality:** Pulli Island, Gulf of Manaar.

Measurements: Diameter of the test: 100 mm.
 Height of the test: 57 mm.
 Diameter of the peristome: 25 mm.

The peristome appears to remain almost constant in size after a certain stage, although the size of the test may increase as the specimen grows older, in this species.

Besides the above specimens, there is one large, wet-preserved specimen from Shingle Island, two large, dry-preserved specimens with spines intact, also from Shingle Island, and one large, dry-preserved, perfectly bleached, white test of this species without spines, probably from the same locality and one disarticulated Aristotle's Lantern (masticatory apparatus of a specimen of this species with the individual parts labelled—all exhibited in the Gallery.

ORDER CAMARODONTA

In this Order the epiphyses of the lantern are enlarged and wide, and meet in suture over the foramen magnum, across the top of each pyramid forming a sort of bar in front of the tooth. The teeth are keeled. The ambulacra are of the diadematoïd or echinoid types or polyporous variants of these types. The spines are solid, without a cortex. The primary tubercles are imperforate. All the four types of pedicellariae are present in large numbers, and the globiferous type is often provided with stalked glands. The auricles of the perignathic girdle generally from arches over radial structures passing on to the corona.

In the young specimens, the periproct is often occupied by a large plate which is later usually partly absorbed or else replaced by small plates.

Most of the common and more familiar regular urchins of the littoral zone belong to this Order. The existing species are grouped into six families.

Family TEMNOPLEURIDAE

In this family, the test is more or less sculptured by pits and depressions along the sutures and on the plates, and the plates are sutured together by a system of pits and knobs. The gill cuts are mostly shallow. The members of this family are mostly small urchins, with short, brightly coloured or brightly banded spines, and are limited to tropical and subtropical regions, except the Eastern Pacific.

The ambulacral plates are compound, with three elements. Pits or sculpturing are present on the coronal plates dorsally. The ocular plates are all usually exsert.

This large and interesting family contains the smallest of the regular Echinoidea, and many of the most brilliantly coloured forms. This family is reported to be represented in the British Museum collection by more than 600 specimens, belonging to 38 species.

This family is divided into two sections or sub-families, one of which, namely, Trigonocidarinae, contains mostly deep water forms, characterized by sculptured tests, usually of small size (below 20 mm. in diameter), while the other, namely, Temnopleurinae, contains littoral species (sometimes found in waters of considerable depth) whose tests are not sculptured, and are, as a rule, of moderate or large size. Of these, species belonging to the latter subfamily are naturally more numerous and more common and are characterized by great variability and diversity of form and colour. Naturally, species of this family represented in the collection of this Museum belong only to the latter sub-family, the Temnopleurinae, and are all littoral forms.

Sub-family TEMNOPLEURINAE

The test is not sculptured. The species of this sub-family are mostly littoral and possess tests of moderate to large size. Two genera are included in this sub-family, namely, *Temnopleures* and *Salmacis* and both these are represented in the Museum collection.

The compound ambulacral plates are composed of two primaries and an intermediate hemiplate while true sutural pits are present and often undermine the plates.

Genus *Salmacis* Agassiz.

The test is moderately thick, more or less conically ovoid, high, or somewhat flattened, usually over 50 mm. in diameter in the adult state. The pores are trigeminate. The tubercles are crenulated, not perforate, arranged in several vertical rows, at the same time forming regular horizontal rows. The coronal plates at the ambitus each bear 4 to 9 primary tubercles. The median interambulacral spaces are frequently bare. Angular pores are present at the junction of the plates. The abactinal system of plates is prominent. The actinal system is small, with slight indentations. The spines are fine, slender, longitudinally striated and short. One of the most characteristic features of this genus is that the pits on the test are reduced to minute pores at the sutural angles of the coronal plates.

The auricles are often high, thin, with high connecting ridges and small, auricular foramen. The ambulacral system is broad. The profile of the test of all species varies greatly in this genus.

Two species of this genus are represented in the Museum collection, namely *Salmacis bicolor*, recorded from the Madras Coast, and *Salmacis virgulata*, occurring on Krusadal and Shingle Islands in the Pamban area in the Gulf of Manaar.

The latter species, *Salmacis virgulata*, may be readily distinguished from the former (*Salmacis bicolor*) by the fact that the spines are uniformly purplish blue, while in *Salmacis bicolor* the spines are prettily banded alternately with white and violet.

***Salmacis bicolor* Agassiz.**

FIGURES 27 AND 28.

- Salmacis bicolor*, Agassiz, Val. Mon. Ech. Anat. Genre Echinus, 1841, p. viii.
- Salmacis bicolor*, Agassiz, "Revisio of the Echini", Cat. Mus. Comparative Zoology, Harvard, No. VII, 1872-74, Pt. III, p. 471; Plate viii a, figs. 11-12.
- Salmacis bicolor*, Agassiz, Report of the Scientific Results of the Voyage of "H.M.S. Challenger", Zoology, III, 1880, p. 113.
- Salmacis bicolor*, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of British Museum, 1925, p. 84.
- Salmacis bicolor*, Koehler, Echinoidea, III, R.I.M.S. Investigator, Indian Museum, Calcutta, 1927, pp. 78-80: pl. xiii, figs. 1-4 and 6-11.
- Salmacis bicolor*, Gravely, "Shells and other Animal Remains of the Madras Beach", Full. Madras Govt. Mus., Natural History, V, No. 1, 1941, p.
- Salmacis bicolor*, Hyman, The Invertebrates, Echinodermata, 1955, p. 526.

This is the most common and familiar species of the genus *Salmacis*, and is widely distributed in the Indian Ocean.

The test is moderately thick. The peristome is of moderate size, decagonal and with very slight indentations. The abactinal system (apical system of plates) is large, with broad, genital rings; the genital plates are of uniform size. The madreporic genital plate is only slightly larger. The anal system is covered by a comparatively few large, polygonal plates, carrying small tubercles, irregularly arranged, with smaller ones between them. The ocular plates are irregularly pentagonal, small, excluded from the anal system. The genital plates carry a ring of secondary tubercles near the anal system. The interambulacral space is covered by tubercles of very uniform size, arranged in vertical and horizontal rows, decreasing gradually from the ambitus to the abactinal pole; the vertical rows adjacent to the poriferous zone are slightly larger than the others, as many as twelve vertical rows being present at the ambitus of a moderate-sized specimen measuring 50 mm. in diameter. The coronal plates are narrow. The plates carry in addition to the primary spines an irregular horizontal row of small granules above the primary tubercles. In the ambulacral space, the two primary vertical rows adjacent to the poriferous zone are as large as the interambulacral primaries. The median space is filled with from four to five irregular vertical rows of somewhat smaller tubercles. In large specimens, the second inner vertical rows are frequently as large and regular as the outer row. On the ambulacral plates a few granules occupy the upper part of the coronal plate.

On the actinal (oral) side of the test at the ambitus and below it, the tubercles increase rapidly in size, and cover the whole actinal surface close to the actinostome with tubercles of very uniform size arranged in regular, horizontal rows, but becoming slightly smaller towards the peristome (actinostome). The median ambulacral tubercles, however, diminish gradually in size towards the actinostome. The poriferous zone is broad. The pores are large, regularly arranged in arcs of three pairs. The spines of the test above the ambitus are short, pointed and slender, and are of a greenish colour and banded with five or six transverse bands of violet. The spines of the actinal surface are much longer and broader, frequently flattened, gradually tapering and blunt at the extremity and banded similar to the spines above the ambitus. Sometimes the spines are prettily banded in red and yellowish green. The colour of the test, when dry, is yellowish brown. The pores at the median junctions are small, and the horizontal sutures of the coronal plates slightly furrowed.

The specimens are usually about 45 to 50 mm. in diameter (test), but the largest specimens measure 77 mm. in diameter and 49 mm. in height. Specimens of this species have been collected from a wide range of localities including the Red Sea, Indian Ocean, Mozambique, Ceylon, Zamboangan, Madagascar and Zanzibar. The smallest specimen of this species in the British Museum collection from Macclesfield Bank is described as being about 7 mm. in diameter, with the spines 7 mm. long.

There is considerable variation in the colour of the specimens in this species. Clark (*loc. cit.*, p. 84) cites the instance of certain specimens of this species from Madagascar in which the test shows no red whatever, looking more like a brightly coloured specimen of *Salmacis sphaeroides*, and there is much violet on the primary spines; the small spines are violet and reddish brown and the bases of the abactinal primary spines are tinged with red. Sometimes, the bases of the primary spines and the smaller spines are more strongly reddish.

In *Salmacis bicolor*, the globiferous pedicellariae are very abundant.

Clark (*loc. cit.*), makes specific mention of two specimens of this species in the British Museum collection which are from Madras and states that these are of interest, for while one of them is a typical *Salmacis bicolor*, the other is almost as violet (or purple) and as devoid of red as the specimens from Madagascar in the British Museum collection.

In the Challenger Reports, Agassiz (*loc. cit.*, p. 113), records that the specimens of this species pertaining to the Challenger Expedition were collected from Zamboangan and were from a depth of ten fathoms.

This species is common in the Madras Harbour, and Dr. Gravelly, (*loc. cit.*), mentions that when fresh the test of this species is covered with spines characteristically banded with purple and pale green (or yellowish green). In *Salmacis bicolor*, the sutural grooves on the upper part of the shell (test) are much more pronounced than in the next species, *Salmacis virgulata*.

Specimens in the collection.—(i) One specimen; wet-preserved, moderately small.
Locality: Madras Harbour.

The spines on one half of the surface of the test have fallen away, and only the spines in the other half of the test remain intact. The spines are slender, rather short, pale yellowish white, beautifully cross-banded with purple. The tubercles are arranged in regular vertical rows. The spines above the ambitus are rather short while the spines of the actinal (oral) surface are much longer.

Measurements: Diameter of the test: 43 mm.

Height of the test: 29 mm.

Diameter of the peristome: 9 mm.

Average length of the spines on the actinal surface: 14 mm.

Average length of the spines above the ambitus: 10 mm.

(ii) A smaller (younger), wet-preserved specimen.

Locality: Madras.

Spines are persistent throughout the surface of the test. The colour of the spines is faded into dull greyish white and the violet cross-banding is much faded and only faintly visible.

Measurements:

Diameter of the test: 25 mm.

Height of the test: 15 mm.

Diameter of the peristome: 6 mm.

Average length of the spines just below the ambitus: 11 mm.

Average length of the spines above the ambitus: 8 mm.

(iii) One specimen, wet-preserved. Locality: Ennur, obtained from the Fisheries Biological Supply Station, Ennur.

The spines in this specimen have almost completely fallen away. The test is greyish brown with the ambulacral areas appearing as double coppery reddish brown vertical radial zones.

Measurements:

Diameter of the test: 52 mm.

Height of the test: 35 mm.

Diameter of the peristome: 12 mm.

(iv) One slightly smaller (young) specimen, Locality: Ennur, obtained from the Ennur Fisheries Biological Supply Station, Ennur.

This specimen has more of the spines intact on the abactinal side above the ambitus than the previous specimen, but the spines have completely fallen away on the actinal surface. The spines are pinkish violet for about 5 mm. of their length over the basal portion and become yellowish and cross-banded only beyond this basal uniformly pinkish violet portion:

Measurements:

Diameter of the test	48
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Height of the test	35
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Diameter of the peristome	12
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Average length of the spine on the abactinal side:	8 mm.
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Salmacis virgulata Agassiz & Desor.

FIGURE 29

Salmacis virgulata, Agassiz and Desor, Ann. Sci. Nat (3), VI, 1846, p. 359.

Salmacis virgulata, Döderlein, Bericht. über die v. Semon gesamm. Echinoidea, in SEMON. Zool. Forschungs. V. Jen. Benkschr., VIII, 1903, p. 70 (712); pl. LXII, figs. 2 and 2 a.

Salmacis virgulata, Meijere, Echinoidea, Siboga-Expeditie, XLIII (livr. XIV), 1904, pp. 83 and 229 (Key); pl. XVII, figs. 273 a — b.

Salmacis virgulata, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, 1925, p. 87.

Salmacis virgulata, Koehler, R. Echinoidea, III R. I. M. S. Investigator, Indian Museum, Calcutta, pp. 81-82.

Salmacis virgulata, Gravely, "Littoral Fauna of Krusadai Island, in the Gulf of Manaar", Bull. Madras Government Museum, Natural History, I, No. 1, 1927, p. 171.

Salmacis virgulata, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum, Natural History, V, No. 1, 1941, pp. 88, 89.

This species occurs on both Krusadai and Shingle Islands near Pamban in the of Manaar area. but is not common on either. It has also been recorded from the Madras Beach (loc. cit., pp. 88, 89). The largest specimen collected from the Pamban area has a shell about 12 cm. in diameter, but no others have been found nearly as large as this. It was found on Shingle Island.

This species can be readily distinguished from the preceding one (*Salmacis bicolor*) by its shorter and uniformly purplish blue spines and by the absence of deep transverse grooves between the plates of the shell. Unlike the preceding species, the primary spines

are not banded. The colours of the spines in specimens from different localities are often diverse, the base and tip being often of different colours. The coronal plates are separated from each other only by sutures, the edge of which may be slightly bevelled.

The British Museum collection reported by Clark (*loc. cit.*, p. 57) is said to contain a good series of fourteen specimens of this species from Tuticorin, of which the largest consisting of a bare test only, is 66 mm. in diameter and 43 mm. in height. The other are said to range from 30 to 50 mm. in diameter and are described as being greenish white, with the primary spines bright reddish violet, more or less white-tipped. A specimen of Australia in the British Museum collection is reported to show interesting peculiarities: the test in his particular specimen is described as being low, and 25 mm. in diameter and 12.5 mm. in height. Above the ambitus it is wholly white, but the primary spines are violet with white tips. The specimen is said to resemble *Salmacis dussumieri* strongly.

Meijere (*loc. cit.*, p. 83) referring to the specimens of this species in the Siboga Expedition collections examined by him reports specifically on three specimens of this species of diameter 68–78 mm. The spines are reported to be red, with white base and tip. The white colour of the base is said to extend to more than the length of the spines on the apical side. On the oral side in two of these specimens, the spines are found to be completely white. In the third specimen, the spines have broad, purplish horizontal bands just before the tips. The globiferous pedicellariae are abundant and relatively short and broad. The walls of the pedicellariae are found to bear simple, calcareous, C-shaped bodies, without teeth.

Specimens in the collection.—The following five wet-preserved specimens of this species are contained in the Museum's Reference Collection:—

- (i) One specimen. Locality: Madras.

The test is more or less subspherical and conically raised and arched on the abactinal side. The test is creamy yellow in colour with the interambulacral areas radiating as narrow, brownish bands from the apex. The primary spines are uniformly deep purplish, but their basal portion is pale yellowish white. The secondary and miliary spines are slender and whitish. The spines are present only over a portion of the surface in the present specimen, having fallen away from the remaining portions. The spines on the actinal surface (oral surface) are longish, more or less uniformly whitish or only faintly tinged with violet and they are densely crowded and point downwards.

Measurements: Diameter of the test: 65 mm.

Height of the test: 45 mm.

Diameter of the peristome: 15 mm.

Average length of the primary spine: 3 mm.

- (ii) One young specimen in good condition. Locality: Shingle Island.

This is a young specimen, rather small. The test is almost spherical, more or less flattened on the actinal surface and highly and convexly arched on the abactinal side. The spines are rather short, uniformly deep purplish and densely crowded.

Measurements: Diameter of the test: 37 mm.

Height of the test: 25 mm.

Diameter of the peristome: 9 mm.

Average length of a spine: 5 mm.

The colour of the test in this specimen is uniformly dirty greyish brown. The peristome is greyish white.

- (iii) One young specimen. Locality: Krusadai Island, 1925.

This young specimen is also fairly small and more or less of the same size and colour as the preceding specimen from Shingle Island. The spines are uniformly dark purplish, while the colour of the test is a pale dirty greenish brown. The peristome is dark greenish grey.

Measurements: Diameter of the test: 37 mm.
 Height of the test: 27 mm.
 Diameter of the peristome: 9 mm.
 Average length of a spine: 5 mm.

(iv) One specimen, acquired from the Ennur Fisheries Biological Station; the original locality (collection spot) is not known. The specimen is wet-preserved, with the bare test only intact, and with the spines fallen away for the most part and the remnants of only a few scattered spines persisting. The test is moderate-sized, sub-spherical, more or less flattened on the oral side and conically raised and arched on the abactinal side. The test is pale, creamy yellowish white, with the interambulacral areas showing as pale, brown bands radiating from the apex. The few stumps of the spines still persisting on the test are more or less uniformly purplish, with pale yellow basal portions.

The Aristotle's Lantern is well seen as a whitish conical structure partly projecting through the mouth in the centre of the peristomal membrane in the present specimen. The tubercles on the actinal surface, which are well seen in the present specimen, are closely crowded.

Measurements: Diameter of the test: 56 mm.
 Height of the test: 36 mm.
 Diameter of the peristome: 12 mm.
 Average length of the persisting spines: 5 mm.

(As the spines are mostly broken, their true length cannot be determined accurately in the present specimen).

(v) One young specimen, with moderately small test, somewhat depressed.
 Locality: Tuticorin.

The test is rather bare, with most of the spines dropped away and only a few persisting. The spines are uniformly purplish, with the basal portion pale yellowish white. The test is pale dirty greyish white, or dull greenish white, with the interambulacral areas marked as darker radiating zones.

Measurements: Diameter of the test: 38 mm.
 Height of the test: 21 mm.
 Diameter of the peristome: 10 mm.
 Average length of a spine: 6 mm.

Genus *Temnopleures* Agassiz.

This genus is characterized by the presence of pits on the plates of the aboral part of the corona.

The test is regularly arched, more or less conically avoid; the actinal part of the test is more or less concave. The primary tubercles are crenulate, imperforate, forming two principal vertical rows in each area. The corneal plates at the ambitus bear 1-3 (rarely 4) primary tubercles. The pores are arranged in simple rows, but forming more or less undulating and irregularly arranged zones. The angles of the plates are separated by deep lateral and vertical grooves in the ambulacral as well as in the interambulacral areas. The spines are long, slender and fluted, especially those near the ambitus. Those of the upper part of the test are shorter, though proportionately equally fine and slender. The auricles are broad, with high connecting ridges and auricular foramen.

The species included in this genus are mostly of moderate to small size, seldom more than 50 mm. in diameter

A single species, *Temnopleure toreumaticus*, which is the commonest and most widely distributed species of this genus in the Indo-Pacific Region is represented in the Museum collection by several specimens, both from the Madras and Pamban areas.

***Temnopleures toreumaticus* (Leske).**

FIGURES 30 AND 31.

- Cidaris toreumatica*, Leske, Additam ad Klein, Natural. Disp. Echinoidea., 1778, p. 155.
- Temnopleures toreumaticus*, Agassiz, Report of the Scientific Results of the Voyage of H.M.S. Challenger, Zoology, III, 1880, Echinoidea, p. 107.
- Temnopleures toreumaticus*, Tenison-Woods, "The Echini of Australia", Proc. Linn. Soc., N.S.W. Wales, Vol. II, 1878, p. 159 and 342.
- Temnopleures toreumaticus*, Tenison Woods, "On some new Australian Echini", Ibid., 1880, p. 289.
- Temnopleures toreumaticus*, Tenison Woods, "Habits of Echini", Ibid., V, p. 200.
- Temnopleures toreumaticus*, Bell, "On some genera and species of the Temnopleuridae", Proc. Zool. Soc. London, 1880, p. 424.
- Temnopleures toreumaticus*, Bell, "On some points in the Morphology of the test of the Temnopleuridae", Journ. Linn. Soc. London, Zoology, XVI, p. 350.
- Temnopleures toreumaticus*, Bell, "Rep. Zool. Coll. of the Voyage of H.M.S. Alert", London, 1884, p. 119.
- Temnopleures toreumaticus*, Döderlein Seeigel von Japan und den Liu-Kiu-Inseln Archiv. f. Naturg. Jhg., LI, p. 87.
- Temnopleures toreumaticus*, Duncan, "On the Perignathic Girdle of Echinoidea", Journ. Linn. Soc. London, Zoology, XIX, 1886, p. 190.
- Temnopleures toreumaticus*, Bell, Echinoderm Fauna of Ceylon, Scientif. Transact. R. Dublin Soc. (2), III, p. 651.
- Temnopleures toreumaticus*, Bell, "Report on a Collection of Echinoderms made at Tuticorin, Madras" Proc. Zool. Soc. London, 1888, p. 33.
- Temnopleures toreumaticus*, Ramsay, Catalogue of the Echinodermata in the Australian Museum, Echini, 1885, p. 46.
- Temnopleures toreumaticus*, Duncan and Sladen, Report on the Echinoidea of the Mergui Archipelago, Journ. Linn. Soc. London, Zoology, XXI, p. 317.
- Temnopleures toreumaticus*, Duncan, Echinoderms and Arthropods from Japan, Proc. Acad. Nat. Sci. Philadelphia, 1891, p. 214.
- Temnopleures toreumaticus*, Bedford, "On Echinoderms from Singapore and Malacca", Proc. Zool. Soc. London, 1900, p. 280.
- Temnopleures toreumaticus*, Anderson, "On some Indian Echinoidea", Journ. Asiatic Soc. Bengal, LXVIII, 1894, p. 188.
- Temnopleures toreumaticus*, Bell, in Gardiner's Fauna and Geography of the Maldives and Laccadive Archipelagoes, p. 231.

- Temnopleures toreumaticus*, Meijere, Echinoidea, Siboga Expeditie, XLIII (= livr. XIV), 1904, pp. 80-31 and p. 228.
- Temnopleures toreumaticus*, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the British Museum, 1925, p. 82.
- Temnopleures toreumaticus*, Gravely, "Littoral Fauna of Krusadai Island, in the Gulf of Manaar", Bull. Madras Government Museum Natural History, 1, No. 1, 1927, p. 170.
- Temnopleures toreumaticus*, Gravely, "Shells and Other Animal Remains of the Madras Beach", Bull. Madras Government Mus. Natural History, V No. 1, 1941, p. 88, figs. 30, 2.
- Temnopleures toreumaticus*, Clark, A.H., "Echinoderms from the Marshall Island", Proc. United States National Museum, Vol. 102, 1952, p. 270.
- Temnopleures toreumaticus*, Hyman, The Invertebrata, Echinodermata, 1955, p. 526.

This is one of the commonest species of Regular Echinoids met with on the Indian shores particularly in the Pamban area in the Gulf of Manaar and is widely distributed in the Indo-Pacific Region. Most of the specimens in the Museum collection are from Kutikal Point, in the Gulf of Manaar, but it has also been found on Krusadai Island. It is a moderately small form of a somewhat dull greyish colour and rather long and more or less distinctly banded spines. There is a great deal of variation in the size, colour and colour pattern of this species. Specimens of this species from Japan are said to be very dark, both test and spines being coloured deep olive or blackish brown, whereas specimens from Ceylon and Tuticorin are very light-coloured.

This is one the earliest known species of Echinoids and has been described and figured by many early authors. It is easily distinguished by its rather small size and characteristic, long, slender, banded spines. The tubercles form two principal, vertical rows in each area.

The anal system is of moderate size, covered by a large number of irregular plates. The genital ring is broad; all the ocular plates are excluded from the anal area. The genital plates are solid, prominent, triangular, with a well marked genital opening towards the extremity of the irregularly triangular genital. The madreporic genital is only slightly larger than the others; the ocular plates have rounded edges, with a deep pit in the angle of junction with the genital plate.

In the interambulacral space, there are for each plate along the horizontal suture two deep rectangular furrows, separated by the principal row of primary tubercles. The outer pit is about half as small as the pits running to the median line. At the median line, the pits terminate in an almost vertical line; towards the other extremity, the pits are somewhat pointed. The shape of the outer pit is truncated towards the poriferous zone. The principal vertical row of primaries form a connected line from the abactinal pole to the actinostome (peristome), while in all the other vertical rows the tubercles are disconnected by the deep pits of the sutures of the plates.

There are at the ambitus four vertical rows of tubercles of nearly uniform size—all, however, except the principal one, diminishing rapidly in size towards the abactinal pole, which extend a little distance above the ambitus as minute secondaries. The tubercles of the principal vertical rows are surrounded by numerous minute secondaries. Below the ambitus, the tubercles are very uniform, gradually decreasing in size to the actinostome (peristome). The furrows on the actinal surface become reduced to small rectangular pits along the median line, and next to the poriferous zone. In the ambulacral space, there are two principal vertical rows of tubercles adjoining the poriferous zone; the furrows run

from the base of the tubercles of the median line, as in the median inter-ambulacral space. These primary tubercles are but slightly smaller than the inter-ambulacral tubercles at the ambitus, and diminish very gradually in size towards the abactinal pole.

The median ambulacral space is occupied by two vertical rows of disconnected tubercles of very unequal size, the one being composed of tubercles nearly as large as the primaries near the ambitus, but rapidly decreasing in size, while the other is made up of minute secondaries. At the base of the primaries, there are, towards the median side, a few very small secondaries. On the actinal side of the ambulacra, as in the inter-ambulacral region, the pits become very small. The tubercles are of uniform size, with irregular horizontal lines of small secondaries along the sutures of the plates. The poriferous zone is broad, with minute secondaries along the sutures of the plates. A vertical row of somewhat larger tubercles is present at the extremity of the ridges and on the outer edge of the zone. The auricles are high, thin, with high, connecting ridges and minute foramen.

The spines are long, quite flattened, of a pink colour, with three or four purplish transverse bands. The actinal membrane is bare; the ten buccal plates are prominent, though not large. The actinostome (peristome) is small, scarcely indented, somewhat sunken. The test of dried specimens is usually of a uniform, drab colour. The test generally averages from 45 to 55 mm. in diameter.

This is the only common species of regular sea urchins, the test of which is strong enough to be washed up intact on the beach, and the small, greyish brown dry shell of this species has been frequently found washed up on the Madras Beach. Dr. Gravely (*loc. cit.*, 1941, p. 88), reports that this species is abundant in the Madras Harbour, with its long and slender, red-banded white spines, the bands being somewhat narrow and fading out towards the base.

Specimens in the collection.—There are numerous wet-preserved specimens in the Museum collection.

(i) Three specimens, of which one is very small and apparently a young specimen, and another is also young, but is slightly larger. Locality: unknown.

These specimens are all pale whitish brown, with long, slender spines, white, beautifully cross-banded with chocolate brown. In the largest specimen in this lot, most of the primary spines on the abactinal surface have dropped away, but the secondary and miliary spines are persistent. A few, small, whitish, gastropod shells attached parasitically on the abactinal side of the test are also present in this large specimen.

Measurements:

(a) Large specimen:

Diameter of the test: 37 mm.
Height of the test: 20 mm.
Diameter of the peristome: 7 mm.
Average length of the primary spine: 15 mm.

(b) Medium-sized young specimen:

Diameter of the test: 23 mm.
Height of the test: 14 mm.
Diameter of the peristome: 6 mm.
Average length of the primary spine: 14 mm.

(c) Small young specimen:

Diameter of the test: 16 mm.
Height of the test: 9 mm.
Diameter of the peristome: 4 mm.
Average length of the primary spine: 15 mm.

It would appear from the above measurements that the primary spines attain almost their maximum size in this species even in comparatively young specimens.

(ii) One medium-sized young specimen. Locality: Tuticorin.

The specimen is dull greyish brown on the abactinal surface and pale whitish brown on the apical side. The primary spines over the greater part of the abactinal side in this specimen have mostly dropped away, but towards the ambitus, they are present and are longish, and projecting outwards at the sides. The characteristic chestnut brown banding of the spines is distinct, but rather paler and more faded than in fresh specimens.

Measurements: Diameter of the test: 30 mm.
Height of the test: 17 mm.
Diameter of the peristome: 7 mm.
Average length of a primary spine: 18 mm.

(iii) A medium-sized young specimen. Locality: Ennore, Madras.

The colour of this specimen is dirty dull greenish brown above, and pale whitish brown below. The primary spines are lacking or are scarce on the upper part of the abactinal surface; but they become more numerous towards the ambitus where they project outwards at the sides. The characteristic chestnut banding on the primary spines is bold and distinct. The primary spines in this specimen are rather shorter in average size than is usual among the other specimens of this species in the Museum collection.

Measurements: Diameter of the test: 26 mm.
Height of the test: 16 mm.
Diameter of the peristome: 5 mm.
Average length of a primary spine: 12 mm.

(iv) Twenty-three young specimens, most of them being very small. Locality: Madras.

These specimens are all dirty brownish or dull greenish brown above and pale whitish brown below. The spines are long, slender and strongly developed, those at the sides being the longest and projecting strongly outwards. The characteristic chocolate brown banding of the primary spines is distinct in all the specimens in this lot, although faded somewhat in some specimens. The spines are very slender and elongate.

The specimens range from very tiny ones measuring hardly 11 mm. in diameter to somewhat larger ones measuring nearly 2 mm. in diameter.

Measurements: (of the smallest specimen in this lot):—
Diameter of the test: 11 mm.
Height of the test: 8 mm.
Diameter of the peristome: 4 mm.
Average length of a primary spine: 7 mm.

Many of the smaller of the young specimens are not much larger than the above specimen.

Measurements: (of the largest specimen in this lot):
Diameter of the test: 20 mm.
Height of the test: 12 mm.
Diameter of the peristome: 5 mm.
Average length of a primary spine: 12 mm.

The other specimens in this lot are intermediate in size between these two extremes.

(v) Four specimens, one of them being a fairly large and adult specimen, and the three others being smaller and younger specimens. Locality: Mandapam, Gulf of Manaar.

These specimens are dirty greyish brown. many of the primary spines, especially on the abactinal surface have dropped away; the spines persist only mostly at the sides around the ambitus and project outwards. Except in one specimen (i. e., the largest among the young specimens) the cross banding of the primary spines is very faintly marked, and in one of the younger specimens the spines are almost uniformly greenish brown with only very feeble indications of the cross-banding.

Measurements: (a) Largest specimen (adult):

Diameter of the test: 40 mm.

Height of the test: 26 mm.

Diameter of the peristome: 9 mm.

Average Length of a primary spine: 20 mm.

(b) Largest of the three young specimens:

Diameter of the test: 33 mm.

Height of the test: 16 mm.

Diameter of the peristome: 17 mm.

Average length of a primary spine: 13 mm.

(c) Smallest of the three young specimens:—

Diameter of the test: 20 mm.

Height of the test: 13 mm.

Diameter of the peristome: 4 mm.

Average length of a primary spine: 14 mm.

(d) The medium-sized specimen among the three young specimens (It is in this specimen that the spines are almost uniformly greenish brown):

Diameter of the test: 24 mm.

Height of the test: 14 mm.

Diameter of the peristome: 5 mm.

Average length of a primary spine: 21 mm.

(vi) Three specimens, two of them being fairly large and almost adult and one slightly smaller. Locality Krusadai Island.

All these three specimens are rather dark brownish in colour and the brown cross-banding of the spines is very feebly marked in all these specimens.

Measurements: (a) Largest specimen:

Diameter of the test: 40 mm.

Height of the test: 27 mm.

Diameter of the peristome: 9 mm.

Average length of a primary spine: 10 mm.

(b) Medium-sized specimen:

Diameter of the test: 38 mm.

Height of the test: 25 mm.

Diameter of the peristome: 8 mm.

Average length of a primary spine: 15 mm.

(c) Smallest specimen:

Diameter of the test: 31 mm.

Height of the test: 21 mm.

Diameter of the peristome: 7 mm.

Average length of a primary spine: 12 mm.

The primary spines have dropped off extensively in these specimens, especially from the abactinal surface.

Besides the above specimens in the Reference Collection there are three dry-preserved greyish brown tests and one wet preserved specimen of this species with spines intact from Krusadai Island in the Gulf of Manaar, exhibited in the Gallery Collection.

Family TOXOPNEUSTIDAE

The members of this family originally included in the larger family Echinidae, but were later separated into a distinct family, the Toxopneustidae. In this family the test lack sculpturing, and is well covered with spines of short to moderate length. The ambulacral plates are of the Echinoid type, or a polyporous variant of that type and the gill cuts at the edge of the peristome are sharp and deep.

This family is represented in the Museum collection by a single species belonging to the genus *Toxopneustes*, namely, *Toxopneustes pileosus*, which is the commonest and most widely distributed species of the family.

Genus *Toxopneustes* Agassiz.

In this genus, a primary tubercle occurs on every other ambulacral plate only (or on every second, third or fourth ambulacral plate); the three pore-pairs of these plates are placed somewhat horizontally, so that they tend to form three vertical series. The gill cuts are deep and sharply defined. The pore-pairs are generally arranged in arcs of three. The poriferous area is not half as wide as the interporiferous area. The size of these sea urchins is generally large. This genus is also notable for the excessively numerous globiferous pedicellariae, which are of two sizes, both being provided with stalk glands. The smaller type, usually held wide open, covers the test, giving a flower-like appearance which is distinctly defined by a white border formed by the densely packed spicules that occur on the edges of the valves.

The most common species of this genus is *Toxopneustes pileosus*, widely distributed in the Indo-West Pacific Region, and this is also the only species of this genus contained in the Museum collection.

Toxopneustes pileosus (Lamarck).

Figure 32

Echinus pileosus, Lamarck, Histoire naturelle des Animaux sans Vertebres III, 1816, p. 45.

Echinus pileosus, Valenciennes, Voy. Venus Zooph., 1846, plates VIII and IX.

Toxopneustes pileosus, Agassiz, Al., Mon. Ech. Hist. Nat. Echinodermes, 1841, p. 7.

Toxopneustes pileosus, Agassiz, Al. Revision of the Echini, Cat. Mus. Comp. Zool., Harvard, VII, 1872-74, pt. iii, pages 497-499, pl. viii b, figs 1-2; pl. xxv, figs, 20, 21; pl. xxxviii, figs. 16 and 17.

Toxopneustes pileosus, Agassiz, Al., Report of the Scientific Results of the Voyage of "H.M.S. Challenger", Zoology, III, 1880, p. 117.

- Toxopneustes pileosus*, Walter, Ceylon's Echinodermen, Jen. Ztschr. f. Naturw. XVIII, p. 375.
- Toxopneustes pileosus*, Döderlein, Seeigel von Japan und den Liu-Kiu-Inseln. Archiv. f. Naturg., XLI, 1885, p. 98.
- Toxopneustes pileosus*, Sluiter, Nachtragliches über die Echinodermen-Fauna des Java-Meeres. Naturk. Tijdschr. Nederl. India, XLIX, p. 110.
- Toxopneustes pileosus*, Döderlein, Echinodermen von Ceylon, Zool. Jahrb. Abth. f. Syst., III, 1888, p. 838.
- Toxopneustes pileosus*, Ives, Echinodermes and Arthropods from Japan, Proc. Acad. Nat. Sci. Philadelphia, 1891, p. 210.
- Toxopneustes pileosus*, Koehler, Echinodermes recueilles par M. Korotnev auxiles de la Sonde, Mem. Soc. Zool. France, 1895, p. 414.
- Toxopneustes pileosus*, Ludwig, Echinodermen des Sansibargebietes (ges. von VOETZKOW), Abhandl. Senckenb. Naturr. Gesellsch., XXI, p. 55.
- Toxopneustes pileosus*, Pfeffer, Echinodermen von Ternate, Abhandl. Senckenb. Naturf. Gesellsch., XXV, p. 83.
- Toxopneustes pileosus*, Döderlein, Bericht über die v. Semon gesamm. Echinoidea, SEMON, Zool. Forschungsar. V, Jan. Denkschr., VIII, 1902, p. 46 (688).
- Toxopneustes pileosus*, Mortensen, Ingolf-Echinoidea 1. p. 111.
- Toxopneustes pileosus*, Meijere, Echinoidea, Siboga-Expedite, XLII, (= livr. XIV), 1904, p. 92.
- Toxopneustes pileosus*, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, London 1925, p. 123.
- Toxopneustes pileosus*, Hyman, The Invertebrata, Echinodermata, 1955, p. 528.

This is one of the commonest and best known species of *Toxopneustes*, and is widely distributed in the Indo-West Pacific Region.

This species is subject to considerable individual variation, particularly with regard to certain characters such as the width of the poriferous zone, the size of the pores, the proportions of the peristome, the concavity of the actinal surface and the less or more strongly pronounced conical profile of the test.

In adult specimens the arrangement of the pores is in three apparently independent vertical rows. The size of the pores varies greatly in the same specimen in the different ambulacra, and even in the different vertical rows of the same poriferous zone, either the inner or the outer row having the exterior pore the largest. In typical specimens, the arrangement of the pores is uniform. In specimens where there are at the ambitus twelve vertical rows of tubercles in the interambulacral space, there are eight in the ambulacral region. Only one vertical row on each side of these regions extends to the abactinal system; the others extend to varying distances above the ambitus. The miliaries and secondaries are arranged in horizontal rows, forming a simple network round the scrobicular circle of the primaries.

The abactinal system is compact; the madreporic genital plate is very prominent. The genital openings are large, and occur near the apex of the plates; the genital and ocular plates carry one large tubercle, with secondaries and miliaries arranged round the scrobicular circle as round the primaries of the test. The anal plates are small, smooth, oblong, with a few, large, triangular ones on the side opposite the anus. The spines

above the ambitus are short, moderately stout; those of the lower side, however, are much longer and more slender. The outline of the test from above is pentagonal, with the re-entering angle in the median interambulacral space; the ambulacra project beyond the general outline of the test. In profile, the outline of the test is generally somewhat conical, though young specimens are more regularly arched and when quite small, almost globular; in older, fully grown specimens, the shape is sometimes quite globular. The peristome is more or less depressed and the lower surface concave. In medium-sized and large specimens, the depth of the actinal cuts varies considerably.

In young specimens, the arrangement of the pores is in arcs of three pores each. The peristome is not sunken and the actinal cuts are only slightly developed. The secondary and primary tubercles are arranged somewhat irregularly upon the plates both of the ambulacral and interambulacral regions, forming only two regular vertical rows in each area. The test of young specimens is usually ornamented with spirally arranged bands of colour, extending across the ambulacral and interambulacral areas in disconnected patches, the bands becoming narrower towards the abactinal pole. With increasing age, these bands become more and more indistinct, and can often be traced even in the largest specimens examined.

Typically, the specimens are more or less red in colouration when fresh, especially on the smaller spines, but the general appearance is often variegated.

This species has been recorded from quite a wide range of localities in the Indo-West Pacific Region. The list of localities include Muscat, Aden, Mozambique, Mauritius, Seychelles, Andaman Islands, Philippine Islands, Zamboanga, Japan and Sagami Bay. The largest specimens are from Mauritius, attaining about 145-150 mm. in diameter. The smallest specimen of this species in the British Museum collection (from Macclesfield Bank) is reported to measure only 14 mm. in diameter. The spines in the living specimens of this species are reported to be poisonous.

Specimens in the collection.—Two moderate-sized, dry-preserved specimens (tests alone) are represented in the collection of this Museum, both being exhibited in the Gallery, Locality: Tuticorin.

The specimens consist only of the dry tests, without the spines. The two tests are more or less of the same size and colour, but one is slightly more faded. The tests are dark brownish, with concentric, regularly spaced, rather broad, yellowish brown bands. There are ten distinct double rows of primary tubercles radiating from the apex downwards. The test is rather large, depressed, with a convex, abactinal side and flattened, slightly concave, actinal side. The poriferous zones appear as narrow, radiating bands in between the double rows of primary tubercles.

Only one vertical row of tubercles on each side of these regions extends to the abactinal system; the others extend to varying distances above the ambitus.

The outline of the test is indistinctly pentagonal at the ambitus.

Measurements: (a) Large specimen:

Diameter of the test: 96 mm.

Height of the test: 47 mm.

(b) Smaller specimen:

Diameter of the test: 93 mm.

Height of the test: 42 mm.

The measurements of the peristome could not be determined in these two specimens, as the specimens are firmly glued on to the display boards by their oral surfaces and hence are not detachable easily without risk of damage.

The secondary and miliary tubercles in these specimens are arranged in regular horizontal and vertical rows which intersect to form a regular, uniform network of tuberculation throughout the surface of the test.

Genus *Tripneustes* Agassiz.

The genus *Tripneustes* comprises rather large-sized urchins with long, narrow, ambulacral plates, so that the primary tubercles occur on every two to four plates and the three pore pairs are horizontally placed, forming distinct, vertical (meridional) rows. In this genus, the epiphysis of the lantern bear a pair of curved processes around each tooth. The gill cuts are deep; the poriferous areas are very wide, more than half the width of the interporiferous areas. The pore pairs are arranged in three more or less well separated vertical rows. The size of these urchins is generally very large.

This genus is represented in the Museum collection by a single species, *Tripneustes gratilla*, which is a common littoral species found in the Western Tropical Pacific Region, as far as Hawaii.

Tripneustes gratilla (Linné).

FIGURE 33.

- Echinus gratilla*, Linné, Syst. Nat. Ed. X, 1758, p. 664.
- Cidaris variegata*, Leske, Additam ad Klein, Nat. Disp. Echin., 1778, p. 155.
- Tripneustes gratilla*, Loven, 1887, Bih. Svensk. Vet., Akad., Handl., XIII (4), No. 5, p. 77.
- Hipponoe variegata*, Agassiz, Al., "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard, No. VII, 1872-74, pt. III p. 501.
- Tripneustes gratilla*, Tenison-Woods, "The Echini of Australia", Proc. Linn. Soc. N. S. Wales, II, 1878, p. 166.
- Tripneustes gratilla*, Tenison-Woods, "Habits of Australia Echini", Proc. Linn. Soc. N. S. Wales, V, p. 202.
- Tripneustes gratilla*, Tenison-Woods, "On Some New Australian Echini", Proc. Linn. Soc. N. S. Wales, IV, 1880, p. 289.
- Tripneustes gratilla*, Agassiz, Al., Report of the Scientific Results of the Voyage of H.S.M. Challenger, Zoology, III, Echinoidea 1880 p. 118.
- Tripneustes gratilla*, Th. Studer, "Gazelle", Echiniden Monatsb. Ak. Wissensch., Berlin, 1880, p. 876.
- Tripneustes gratilla*, Bell, Rep. Zool. Coll. "Alert", London, 1884, p. 121.
- Tripneustes gratilla*, Walter, Ceylon's Echinoderms, Jen. Ztschr. f. Naturw., XVIII, p. 375.
- Tripneustes gratilla*, Döderlein, Seeigel von Japan und den, Liu-Kiu-Inseln, Archiv. f. Syst., III, 1888, p. 838.
- Tripneustes gratilla*, Ramsay, Catalogue of Echinodermata in the Australian Museum, 1885, p. 51.
- Tripneustes gratilla*, de Loriol, Notes pour servir à l'étude des Echinodermes III, Mem. Soc. Phys. Nat. Genev, 1890, Vol. Supplement No. 8, p. 22.
- Tripneustes gratilla*, Loven, The Linnaean species of Echinoidea, Bih. till Kgl. Svensk. Akad. Handl., XIII, 4, p. 77.
- Tripneustes gratilla*, Farquhar, A Contribution to the History of New Zealand Echinoderms, Journ. Linn. Soc. London, XXVI, p. 187.

- Tripneustes gratilla*, Pfeffer, Ostafrikanische Echiniden, ges. von Dr. Stuhlmann, Mittheil. Naturh. Mus. Hamburg, III, p. 46.
- Tripneustes gratilla*, de Loriol, Echinodermes de la Baie, d'Amboine, Revue Suisse de Zoologie, 1893, p. 373.
- Tripneustes gratilla*, Sluiter, Die Echiniden sammlung des Museums zu Amsterdam Bijdragen tot de Dierkunde, XVII, 1895, p. 71.
- Tripneustes gratilla*, Ludwig, Echinodermen des Sansibargebietes (ges. von VOELTZKOV), Abhandl. Senckenb. Naturf. Gesellsch. Bd., XX, p. 555.
- Tripneustes gratilla*, Pfeffer, Echinodermen von Ternate (ges. von Kükenthal), Abhandl. Senckenb. Naturf. Gesellsch. Bd. XXV, p. 83.
- Tripneustes gratilla*, Döderlein, Bericht. über die v. Semon gesamm. Echinoidea in SEMON, Zool. Forschungsr. V, Jen Denkschr., IIIV, 1902, p. 46, (688).
- Tripneustes gratilla*, Bell, in Fauna and Geography of the Maldiva and Laccadive Archipelagoes, p. 231.
- Tripneustes gratilla*, Mortenson, Ingolf-Echinoidea, I, p. 13.
- Tripneustes gratilla*, Meijere, Echinoidea, Siboga-Expeditie, XLIII (livr. XIV), 1904, pp. 95 and 230 (Key).
- Tripneustes gratilla*, Clark, H.L., Carnegie Inst., Mar. Biol. Papers, X, pl. XVIII, 1921, fig. 6.
- Tripneustes gratilla*, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, London, 1925, p. 124.
- Tripneustes gratilla*, Clark, A. H., "Echinoderms from Marshall Islands," Proceedings of the United States National Museum, Vol. 102, 1952, p. 271.
- Tripneustes gratilla*, Hyman, The Invertebrata, Echinodermata, 1955, p. 528.

These are sea urchins of large size, common in the Western Tropical Pacific, as far as Hawaii. There is a great deal of variation in form and colour in this species.

The abactinal surface, especially in the interambulacra, are rather sparsely tuberculated. The buccal membrane bears rather numerous plates.

Bare tests of *Tripneustes gratilla* can be readily distinguished from the closely related species, *Tripneustes esculentus*, usually at a glance, by the noticeably barer abactinal interradial areas. While specimens of *Tripneustes gratilla* are not very common except as less than half grown individuals, with the spines on, specimens of *Tripneustes gratilla* are not easily distinguished from *Tripneustes esculentus* of the same size; in general, however, the spines are more slender and more numerous. The proportions of the height to the diameter also vary in specimens from different localities. Some specimens are white, except for the interambulacral areas abactinally, which are dusky. Occasionally, the test is marked with dull pink, but this is rather unusual.

Tripneustes gratilla is described as *Hiponoe variegata* by Agassiz Al., (loc. cit., "Revision of the Echini", p. 501).

As the synonymy shows, this is one of the most variable of the species of Echinoids in general appearance and in outline. Some specimens are nearly globular, others greatly depressed, and still others are with a pentagonal outline from above, and re-entering median interambulacra near the ambitus. The outline in profile varies from depressed to globular or conical. The general appearance of this widely distributed species is such as readily to separate it from the American species of the same genus. The small size of the

tubercles and their smaller number are eminently characteristic of this species. The median ambulacral and interambulacral spaces are generally bare from the abactinal pole to the ambitus, being covered by a few small miliaries spaced wide apart. The anal system is comparatively very large; the abactinal system is more circular and less strictly pentagonal, owing to the smaller size of the genital plates than in the West Indian species. The poriferous zone is also much narrower; the actinostome is large and the spines much more slender.

The colour of the specimens is extremely variable, and is best indicated by the names of some of its synonyms—*violaceus*, *subcoeruleus*, *nigricans*, etc.—showing the range of colouration such as violet, blue and black. The pentagonal specimens (*pentagonus*) generally have a more brownish yellow colouration, much as in the West Indian specimens. The buccal membrane is scarcely covered by calcareous plates. The plates of the anal system are smaller and more numerous than in the West Indian species.

Meijere (*loc. cit.*, p. 95) reporting on the specimens of this species in the Siboga Expedition collection examined by him, records that most of the specimens examined by him in the Siboga collection are strongly flattened. On the contrary, the biggest specimens (from Jedan and Lumu-Lumu), both of a diameter of about 90 mm. are high, conical, and with strong, five cornered (pentagonal) ambitus.

The colour is also reported to vary greatly among the Siboga specimens of this species even in specimens from the same collection site (or station). The spines are reported to be mostly white: sometimes those in the poriferous zones are brownish. The podia are said to be either black, with the terminal part white, or white with black transverse bands or rings, or in still other cases completely white, in the Siboga Expedition specimens of this species. Meijere also reports that the heads of the pedicellariae are coloured black in young specimens of the Siboga collection examined by him.

This species is widely distributed and has been recorded from the Red Sea, Aden, Gulf of Suez, Zanzibar, Mozambique, Cape of Good Hope, Mauritius, Seychelles, Bornet, Philippines, Celebes, Zamboanga, New Guinea, Australia, Torres Strait, New South Wales and Port Jackson, and specimens from all these localities are reported to be represented in the British Museum collection (Clark, *loc. cit.*, p. 124). This species is also recorded from Sandwich Islands, Japan, East Indian Islands, Fiji, Rotuma, Reoul, Reef of Attagor and Reef of Oomaga.

The diversity in form and colour in this species is very marked. The most notable specimens are those from Mauritius, several of which are reported to be curiously depressed, even markedly concave abactinally.

Specimens in the collection.—One wet-preserved specimen. Locality: Tholayirampar, Tuticorin, dredged by the Lady Goschen Expedition in 1927.

The specimen is fairly large, greyish brown, closely covered all over with rather short, brownish spines, tipped with yellowish white. The spines on the abactinal side are longer, more numerous, and more densely crowded and project downwards on the actinal side (oral side). The spines on the oral side are also paler and yellowish white for the greater part showing only faint indications of the brownish colour. The spines are somewhat tapering towards their tips, but are rather blunt and not sharply pointed. The test is somewhat depressed and the peristome is large.

Measurements: Diameter of the test: 100 mm.

Height of the test: 45 mm.

Diameter of the peristome: 30 mm.

Length of a primary spine: 15 mm.

Genus *Gymnechinus* Mortensen.

The test is small, flat; the periproct is excentric, at right; with ocular I and II inserted, or nearly so.

Only a single species, *Gymnechinus robillardi* which is the type of this genus, is represented in the Museum collection. It is said to be common in the vicinity of Ceylon.

***Gymnechinus robillardi* (de Loriol).**

FIGURES 34 AND 35

The specimens belonging to this species are small, with the test flat. The test rarely exceeds 30 mm in diameter. The spines are white. The suranal plate is small, without a tubercle and is in contact with only two granules.

Specimens are recorded from the Gulf of Manaar (Thurston), Ceylon and Mauritius. There is considerable variation in the condition of the auricles; in some, they are well separated, while in others, notably in older specimens, they are fully united. Apparently, this condition is attained only in mature specimens.

Specimens in the collection.—A single small, wet preserved specimen, probably a young specimen, is represented in the Museum collection. Locality: Tuticorin.

The specimen is pale greyish white (or dirty whitish) with the test somewhat depressed and with densely crowded, short, white spines.

Measurements: Diameter of the test: 20 mm.

Height of the test: 11 mm.

Diameter of the peristome: 6 mm.

Length of a primary spine: 3 mm.

Family ECHINIDAE.

In this family, each value of the globiferous pedicellariae bears a single poison sac, has one to several teeth along its sides, and terminates in a single, large, pointed tooth. This family includes the familiar European species, *Echinus esculentus* with its beautiful red test and purplish spines, and the other common Mediterranean rock-boring species, *Paracenirctus lividus*, with dark green test and violet-brown or green spines.

Formerly, the limits of this family were more extensive, and the family originally included several genera such as *Gymnechinus*, *Lytechinus* and *Toxopneustes* which are now separated into a distinct family, the Toxopneustidae.

The ambulacral plates are compound, typically composed of three elements. The ambitus is circular and the test is without pits or sculpturing.

This family is represented in the collection by a single common and widely distributed species, formerly regarded as belonging to the genus *Echinus*, namely *Echinus angulosus*. Since the generic description of *Echinus* will therefore be of interest in this connection, it is furnished below:

Genus *Echinus* Linné.

This genus includes species of regular Echinoids with more or less globular tests, with comparatively small tubercles, smooth, imperforate, of nearly equal size on the two areas, forming but two principal vertical rows upon the coronal plates, upon both areas, the other tubercles being smaller and irregularly arranged. The actinostome (peristome) is small, with but single cuts. The buccal membrane is bare, with only the ten buccal shields. The spines are comparatively stout and often attaining a considerable size and, in some species, even as long as the diameter of the test. The pores are arranged in arcs. The jaws are comparatively weak, the auricles being slender.

The periproct is approximately central; the peristome is not plated. The gill cuts are shallow; the pore-pairs are arranged in arcs of three. The ocular plates are small, exsert (rarely I, or I and V insert); the size of the specimens is usually large often exceeding 75 mm.

Recently, however, the species represented in the Museum collection, namely, *Echinus angulosus*, has been referred to another genus, namely, *Parechinus*, and included in that genus as *Parechinus angulosus* by Mortensen, Clark and other recent authors. Accordingly, the species is described under the genus *Parechinus* in the present account.

Genus *Parechinus* Mortensen.

(Type, *Cidaris angulosa* Leske, 1778, Add. ad. Klein, p. 28).

Ocular I (and often Ocular V) may be insert; buccal membrane with more or less numerous plates, some of which may bear pedicellariæ; a primary tubercle is present on each ambulacral plate. Compared to the members of the typical genus *Echinus*, the size of the specimens in *Parechinus* is often small relatively, and the test is rather low.

Parechinus angulosus (Leske).

FIGURE 36.

Cidaris angulosa, Leske, Add. ad. Klein, 1778, pp. xvii, 28.

Echinus angulosus, Agassiz, Al., "Revision of the Echini" Cat. Mus. Comp. Zool., Harvard, III, 1872-74, p. 489, pt. I, p. 122.

Parechinus angulosus, Mortensen, Deutsch. Sudpolar Exp., Echinoidea, pl. ix, figs. 8 and 10.

Parechinus angulosus, Clark, H.L., Catalogue of the Recent Sea Urchins, (Echinoidea) of the British Museum, London, 1952, p. 117.

Parechinus angulosus, Meijere, Siboga-Expeditie, Echinoidea, p. 88.

The colouration of this species is subject to considerable variation. Usually the colour is red or purple. In young specimens, the primaries may be banded. The primary spines are fairly stout.

The longer, more slender spines — generally tipped with violet, the shafts of all shades between that and the lightest yellow—the thinner test, the greater number of coronal plates, and the structure of the abactinal system, at once separate this species from the closely related *Parechinus miliaris*. There is in the median interambulacral space one principal vertical row of tubercles, but they are small as the secondaries in *Parechinus miliaris*; in the remaining part of the plate, they are arranged irregularly, forming neither vertical nor horizontal lines, more closely packed between the main row and the poriferous zone. Towards the median line, the secondaries and the miliaries occupying the coronal plate are most numerous. The arrangement is the same in the ambulacral space; the median vertical rows are composed of small secondaries scarcely larger than those forming the vertical line in the poriferous zone. The poriferous zone is much broader than in *Parechinus miliaris*, and there are from one to three indistinct vertical rows of tubercles formed from the small secondaries.

The differences in the anal systems of the two species are marked; the genital ring is narrow, and frequently two of the ocular plates reach the anal system, which is comparatively much larger than in *Parechinus miliaris*; the ocular plates are also larger. The secondaries on the genital plates near the anal edge are small, and the

anal plates are but slightly tuberculated. Both in *P. miliaris* and in this species, there are three to four very much larger anal plates, but the rest are small, diminishing in size towards the anal opening. The actinal cuts are more marked than in *P. miliaris*.

The buccal membrane is thin, and is but sparsely covered by limestone plates, which in this species are reduced almost to a minimum.

This species (*Parechinus angulosus*) is widely distributed in the Indian Ocean and adjoining coasts of Africa, and has been recorded from St. Helena, Cape of Good Hope, Simon's Bay (Challenger), St. Sebastian's Bay, Natal, Durban, Mauritius and Port Dalrymple. This is characteristically a South African species, and there is considerable variation in the size of the test and in the colour of the spines and of the test. Some have white spines while others red spines, and yet others have purple spines. There is also an interesting diversity to be noticed in the form of the test. Some are pentagonal at the ambitus while others are nearly circular. The coronal plates vary from 20 to 25 in number. The largest specimens are said to measure 48 mm. in diameter and 24 mm. in height, while the smallest ones are said to measure only from 5 to 6 mm. in diameter.

Specimens in the collection: Two dry-preserved specimens are represented in the Museum collection. They are both exhibited in the Gallery. Locality: Pamban, in the Gulf of Manaar.

The specimens are rather small, uniformly brownish, with numerous, closely crowded, short spines, which are somewhat slender and pointed at the tips. The test is somewhat depressed, with the abactinal side being more or less flattened. One of the specimens is slightly larger than the others.

Measurements: (a) Larger specimen—

Diameter of the test: 25 mm.

Height of the test: 14 mm.

(b) Smaller specimen—

Diameter of the test: 22 mm.

Height of the test: 13 mm.

The diameter of the peristome could not be determined in these specimens as they are firmly glued on to the display board by their oral side and it is not possible to detach them from the board without risk of damage.

Family STRONGYLOCENTROTIDAE.

This family includes regular Echinoids of moderate to large size with polyporous ambulacral plates. Their globiferous pedicellariae are characterized by a long, muscular "neck", and valves without teeth, except the terminal one. The principal genus of this family, *Strongylocentrotus* (which name has been replaced currently by 1st synonymous generic name *Pseudoboletia* Troschel) is represented of several familiar littoral species.

The ambitus is circular; no pits or sculpturing are present on the coronal plates; ambulacral plates compound, usually with four or more elements (rarely three).

Formerly, the members of this family were included in the family Echinometridae, along with the genus *Echinometra* and other genera; now they have been separated into a distinct family, the Strongylocentrotidae.

This family is represented in the Museum collection by two species belonging to the genus *Pseudoboletia*, (= *Strongylocentrotus*).

Genus *Pseudoboletia* Troschel.

(Strongylocentrotus).

The test is low, with the ambitus below the median line; the gill cuts are deep. The buccal plates carry spines.

The species of this genus have the general appearance of *Toxopneustes*. The spines are comparatively longer and the plates of the buccal membrane are thickly covered by small spines. The general arrangement of the primary tubercles is like that of *Toxopneustes*, but the outer vertical row of pores of the poriferous zone consists of twice as many pores as the inner rows, and the pores are arranged in such a way as to form arcs of four pairs of pores. The poriferous zone is comparatively no broader than in the true *Toxopneustes*. This is an interesting genus, forming, as it were, a link between the Echinometridae and the Echinidae.

The test is flattened and curved, thin; the tubercles are small; four pairs of pores are found in an arc; two ocular plates touch the periproct; the gill cuts are rather deep (gill fissures); the auricles are with large foramen and low connecting ridges. It is distinguished from *Boletia* Desor, by the presence of four pairs of pores in each arc.

Two species of this genus, namely, *Pseudoboletia indiana* and *Pseudoboletia maculata* are represented in the Museum collection. The latter is readily distinguished from the former in the test being conspicuously blotched with darker markings and in the primary spines being more slender.

Pseudoboletia indiana (Michelin).

FIGURE 37.

Toxopneustes indianus, Michelin, Ech. et Stel. Annexe A. in Maillard's Notes sur Bourdon, 1862, p. 5.

Pseudoboletia indiana, Agassiz, Al., "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard. 1872-74, pt. I, p. 153; pt. III, p. 456.

Pseudoboletia indiana, de Loriol, Mem. Soc. Phys. Hist. Nat. Geneve, XXVIII, 1883, No. 8, pl. iii, figs. 4-4f.

Pseudoboletia indiana, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, London, 1925, p. 131.

Pseudoboletia indiana, Agassiz, Al., Report on the Echinoidea, "Challenger", Zoology, Vol. III, 1880, p. 107.

The test is rather large, low and depressed, and is somewhat conical in profile. The test is not blotched with darker markings. The pore pairs are arranged in arcs of four. The tuberculation on the test is relatively small in proportion to the size of the test. The primary spines are not banded. They are dull pink or whitish, short and thick. The actinostome (peristome) is fairly large, being considerably more than one-third the diameter of the test. The actinal cuts are rather short and broad, and the interambulacral lips of the cuts are quite well developed. The actinal surface is quite flat and the actinostome (peristome) is not sunken. There are six vertical rows of primaries at the ambitus and an irregular median one. The scrobicular circles are large, with numerous small miliaries arranged parallel to the sutures of the plates and vertically between the primaries. The secondaries are few in number and irregularly scattered. In the median interambulacral space, the primary tubercles become very small and unimportant towards the abactinal pole, and the tubercles of the exterior vertical row also diminish rapidly in size above the ambitus. In the ambulacral space, there are four such primary vertical rows of tubercles, scarcely smaller than

those of the interambulacral space, disappearing towards the abactinal system in the median ambulacral as in the median interambulacral space. The poriferous zone is broader than in the allied species *Pseudoboletia granulata*, and the coronal plates are narrower. The ocular plates are rectangular, there being two of them adjacent to the anal system. The genital plates are very unequal in size, the madreporic genital being much larger than the others.

The test is of a dull yellowish brown ground colour, with darker patch of brown round the abactinal system and a broken ring of similar brown patches in the median ambulacral and interambulacral space about half way from the abactinal pole to the ambitus. A second irregular mottled ring follows the line of the ambitus. The spines are of the same tint as the test, and irregularly mottled or banded with brown.

The size of the buccal apparatus is remarkable in this species; in two specimens of *Pseudoboletia indiana*, which had the test respectively 32 and 25 mm. high, the height of the lantern of Aristotle was 26 and 22 mm. respectively.

This species has been recorded from the Mauritius and the Philippine Islands apart from India. It is also known from Zamboanga (Challenger Expedition). The specimens from Mauritius are reported to be typical. In one specimen of this species in the British Museum collection (Clark, *loc. cit.*, page 131), it is reported that no spines are evident on the buccal plates and the gill cuts are not conspicuous.

Specimens in the collection.—One wet preserved specimen is contained in the Museum's Reference Collection. Locality: Unknown.

The specimen is moderately large, with the test somewhat depressed and flattened on the abactinal side. The test is white, with rows of small tubercles and with concentric rows of brownish patches. The spines are long, slender and pointed at the tips, and are varied in colour. Some spines are pale creamy brown, while others are dark purplish brown or dark chestnut brown. The spines of both colours are intermixed. The spines on the oral surface are mostly uniformly creamy brown.

Measurements: Diameter of the test: 87 mm.

Height of the test: 43 mm.

Diameter of the peristome: 24 mm.

Length of a primary spine: 13 mm.

Pseudoboletia maculata (Troschel).

FIGURE 38.

- Pseudoboletia maculata*, Troschel, Verhandl., Nat. Ver. Preuss. Rheinlande, XXVI, 1869, Sitzungsber, p. 96.
- Pseudoboletia maculata*, Agassiz, Al., "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard, 1872—74, pl. III, fig. 456, (*Pseudoboletia indiana*).
- Pseudoboletia maculata*, Agassiz, Al., "Revision of the Echini Cat. Mus. Comp. Zoology, Harvard, 1872—74, pt III, p. 456 (*Pseudoboletia indiana*).
- Pseudoboletia maculata*, Bell, "On the species of *Pseudoboletia*" Annals of Natural History (5), Vol. XIII, pp. 108—111.
- Pseudoboletia maculata*, Sluiter, Die Echiniden Sammlung des Museums zu Amsterdam. Bijdragen tot de Dierk, XVII, 1895, p. 70 (*Pseudoboletia indiana*).
- Pseudoboletia maculata*, Döderlein, Echinodermen von Ceylon Zool. Jahrb. Abth. f. Syst., III, 1888, p. 835 (*Pseudoboletia indiana*).

Pseudoboletia maculata, Mortensen, Ingolf-Echinoidea, I, p. 118.

Pseudoboletia maculata, Meijere, Siboga-Expeditie, Echinoidea, XLIII (=Livr. XIV), 1904, p. 96 and p. 230 (Key).

Pseudoboletia maculata, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, London, 1925, p. 131.

This species is closely allied to *Pseudoboletia indiana* and resembles it in several respects. The pore-pairs are arranged in arcs of four. The test is conspicuously blotched with darker brown markings. The primary spines are more slender than in the preceding species.

Clark (*loc. cit.*) reports that the validity of this species and its specific distinctness from *Pseudoboletia indiana* are doubtful.

However, the presence of spots and blotches on the test and the comparatively more slender spines at once distinguish this species from *Pseudoboletia indiana*. In *Pseudoboletia indiana*, the spines are dull pink, short and rather stout.

This species has been recorded from India (Madras), Philippine Islands, Philippines, Masbate, Zamboanga (Challenger) and Macclesfield Bank (39 fathoms).

Specimens in the collection.—The dry-preserved specimens, exhibited in the Gallery. Locality: Tuticorin.

The specimens are in rather bad state of preservation. The test is dull earthy brown and the spines are either pale brownish or dark chestnut brown. The spines are more numerous and crowded on the oral surface where they project outwards and downwards. In one of the specimens the spines on the abactinal side have almost completely dropped away. The tubercles on the test are small and rounded and form regular radiating rows. The two specimens are almost exactly equal in size. In one of the specimens, remnants of Aristotle's Lantern are seen within the cavity of the test.

Measurements: Diameter of the test: 73 mm.

Height of the test: 39 mm.

Diameter of the peristome: 22 mm.

Length of a primary spine: 17 mm.

Family ECHINOMETRIDAE.

This is the last family of the Regular Sea urchins and also the last family included in the Order Camarodonta. This family includes small to large forms with round or oval test, with three or more pre-pairs on the ambulacral plates. The ambulacra tend to widen gradually in the oral direction. The globiferous pedicellariae have double poison sacs and may be provided with stalk glands. The chief distinguishing feature of these pedicellariae is the presence of one unpaired tooth near the end tooth in each valve.

The ambitus is more or less elliptical. There are no pits or sculpturing of the coronal plates; the ambulacral plates are compound, with 3 to 19 elements but usually more than four. The oculars are all exsert or becoming insert in sequence V, I, IV. (not I, V, IV as usual).

This is a characteristically tropical family. This family is distinguished from the Echinidae in having more than three pairs of pores each arc, while in the Echinidae the arcs are always composed only of three pairs. The mode of growth of the poriferous zone in these two families is also totally unlike.

[This family is represented in the Museum collection by a single species, *Echinometra mathaei*, belonging to the genus *Echinometra*, which is the principal genus of the family. The species *Echinometra mathaei* is fairly common in the Pamaban area in the Gulf of Manaar and is widely distributed in the Indo-Pacific Region.

Genus *Echinometra* Gray.

The species of this genus have an oval test, but the plane of elongation corresponds neither to Loven's plane nor to Carpenter's plane—although it is almost at right angles to the latter. The test has polyporous ambulacra with up to 16 pore pairs per plate.

This genus is characterized by a markedly asymmetrical, oval test. The ambulacral plates are composed of four to eight elements. The periproct has numerous plates; the spines are moderately stout and short and are not in any way peculiar.

A single species, *Echinometra mathaei* one of the most familiar and widely distributed species of the genus, is contained in the Museum collection.

Echinometra mathaei (de Blainville).

FIGURE 39.

- Echinus mathaei*, de Blainville, Diction. Science Naturelle, XXXVII, 1325 p. 94
- Echinometra lucuntur*, (part), Agassiz, Al., "Revision of the Echini", Illustrated Catalogue of the Museum of Comparative Zoology at Harvard, VII, 1872—74, pt. I, p. 115; pt. III, p. 431; pl. IV b, fig. 4.
- Echinometra mathaei*, Agassiz Al., Challenger Reports, Echinoidea, p. 105.
- Echinometra mathaei*, Koehler, Echinodermes recueilles par M. KOROTNEV aux îles de la Sonde, Mém. Soc. Zool. France, 1895, p. 415.
- Echinometra mathaei*, Ostafrikanische, Echiniden ges von. Dr. Stuhlmann Mitth. Naturh. Mus Hamburg, XIII, p. 46.
- Echinometra mathaei*, Farquhar, "A Contribution to the History of New Zealand Echinoderms", Journ. Linn. Soc. London, Zoology XXVI, p. 188.
- Echinometra mathaei*, Ludwig, Echinodermen des Sansibar gebietes (ges v. VOELTZKOW), Abhandl., Senckenb. naturf., Gesellsch., XXI, p. 554.
- Echinometra mathaei*, Döderlein, Bericht ub. die v. SEMON ges. Echinoidea SEMON, Zool.Forschungs, V. Jen. Denkschr., VIII, 1902, p. 46, (688).
- Echinometra mathaei*, Bell, Willey's Zoological Results, Part II, p. 136.
- Echinometra mathaei*, Bell, in Gardiner's Fauna and Geogr aphy of the Maldive and Laccadive Archipelagoes, p. 231.
- Echinometra mathaei*, Meijere, Echinoidea, Siboga-Expeditie ,XLIII, (=Livr. XIV), 1904, pp. 101102, and 230 (Key).
- Echinometra mathaei*, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, London, 1925, p. 143.

Echinometra mathaei, Gravelly, "Littoral Fauna of Krusadia Island, in the Gulf of Manzar", N.S., N.H. Section, I, No. 1, 1927, p. 171.

Echinometra mathaei, Clark, A.H., "Echinoderms from Marshal Islands", Proc. United States National Museum, Vol. 102, 1952, p. 272.

Agassiz Al., (*loc. cit.*, p. 431) *Echinometra mathaei* as a synonym for *Echinometra lucuntur*, but the latter seems to be a distinct species, distinguished by the pore pairs being disposed in arcs of 7 or 8, or sometimes only 6, whereas in *Echinometra mathaei*, they are arranged in arcs of 4.

This is probably the most abundant species of regular sea urchins in the world and is widely distributed throughout the tropical and subtropical seas of the world. It is smaller than the other common species of regular sea urchin, namely, *Stomopneustes variolaris*. It has a strongly asymmetrical test and the ambulacral areas are much narrower than in *Stomopneustes variolaris*. There is considerable variation in the colour, but generally the spines are paler than in *Stomopneustes variolaris*, and are of a more greenish tint. Rarely, the spines are black and may be very stout.

But in a large series of specimens of this species (*Echinometra mathaei*) from different localities of the world, there is usually considerable variation in the colour of the test and of the spines. The general colouration of the spines ranges from a dark violet to almost straw colour, tipped with violet, or uniform light pink tipped with yellow, and all possible gradations between this and a dark violet shaft with a yellow tip, or a light green shaft, shading into a darker point tipped with yellow, or a lighter shade than the body of the shaft are noticed in this species. The milled ring is generally of a brilliant white colour. The principal characteristic of this species is the shortness of the arcs composing the narrow, poriferous zone, never having more than five pairs of pores, usually only four pore-pairs in each arc. The outer row of ambulacral tubercles is reduced to minute tubercles, though in very large specimens, this outer row of tubercles is more marked, with a tendency to separate one of the pairs of pores from the others. The coronal plates do not greatly increase in size during growth, but increase rapidly in number. The madreporic genital is but slightly larger than the other genital plates, which are uniform in size. The auricles are prominent, connected by a low, interambulacral arch, flattened, anchor-shaped, and with a large, auricular arch. Actinal cuts are well marked, somewhat rounded; the actionstome (peristome) is larger, in proportion to the size of the test, than in any other species of the genus.

Clark, A. H., (*loc. cit.*, p. 272), reporting on the specimens of this species collected from Marshalls Islands, states that those specimens were all mostly small or medium-sized. The largest, from the outer reef flats on the north east-side of Arambiru Island, Eniwetok Atoll, is reported to measure 51 mm. in length, 40 mm. in width and 32 mm. in height.

This species is very widely distributed, and has been recorded from a very wide range of localities. The recorded localities include Egypt, Suez, Red Sea, Persian Gulf, Muscat, Zanzibar, Mozambique, Madagascar, Mauritius, Maldives, Andaman Islands, Borneo, Philippine Islands, Australia, New Guinea, Solomon Islands, New Hebrides, Loyalty Islands, Fiji, Samosa and the Coast of Savaii.

Round about the South Indian Coasts, this species has been recorded from Tuticorin and from the Gulf of Manaar.

This species is represented in the Museum collection by several specimens from Krusadai and Shingle Islands in the Gulf of Manaar area.

Specimens in the collection :

I. Reference Collection :

(1) One young specimen, wet-preserved; Locality : Shingle Island : 1924. The test is rather asymmetrical and elongately ovoid. The test is whitish, with the tubercles large, prominent and closely set. The spines are strong, greenish, with brownish tips, longish and tapering and pointed towards the tip.

Measurements : Long diameter of the test : 25 mm.

Short diameter of the test : 20 mm.

Diameter of the peristome : 6 mm.

Length of a primary spine : 16 mm.

(2) Slightly larger specimen, wet-preserved. Locality : Shingle Island : 1925.

The test is somewhat purplish brown, but the colour of the spines is more or less the same as in the preceding specimen, although appearing slightly more faded and rather greenish grey. The spines at the sides of the test and around the ambitus are the longest and project towards while the spines on the upper part of the abactinal surface and on the oral side are shorter.

Measurements :

Long diameter of the test : 42 mm.

Short diameter of the test : 35 mm.

Diameter of the peristome : 7 mm.

Length of a primary spine : 17 mm.

(3) One specimen (adult), slightly larger than the preceding specimen, wet-preserved. Locality : Shingle Island : 1944.

The spines are greenish grey, with brownish tips. The colour of the test is purplish brown. The spines on the actinal (oral) side are shorter and paler in colour, almost translucent whitish or whitish green.

Measurements :

Long diameter of the test : 47 mm.

Short diameter of the test : 37 mm.

Diameter of the peristome : 8 mm.

Length of a primary spine : 15 mm.

(4) One very small, young specimen, wet-preserved. Locality : Krusadai Island : 1924.

The spines are fairly long, in spite of the very small size of the test. The spines are dull greenish grey, with pale brownish tips. The spines on the oral (actinal) side are short, whitish, comparatively slender and closely crowded together. The longest spines are at the sides are around the ambitus and project outwards.

Measurements :

Long diameter of the test : 18 mm.

Short diameter of the test : 15 mm.

Diameter of the peristome : 4 mm.

Length of a primary spine : 13 mm.

II. Gallery Collection :

(5) One larger, more or less adult, wet-preserved specimen, exhibited in the Gallery. Locality : Krusadai Island.

The spines are dull, somewhat pale greenish grey, whitish towards their bases and pale brownish towards their tips. The spines are very long, acutely tapering and pointed towards their tips. The colour of the test is purplish white.

Measurements:

Long diameter of the test: 38 mm.

Short diameter of the test: 26 mm.

Diameter of the peristome: 6 mm.

Length of a primary spine: 20 mm.

The surface of the spines in all the specimens mentioned above show very fine, longitudinal striations which can be clearly seen under the lens.

The colour of the spines is rather faded owing to prolonged preservation in alcohol in all these specimens, but in fresh and living specimens they tend to be much brighter greenish in colour.

SUBCLASS IRREGULARIA

(= EXOCYCLICA)

This Subclass includes Echinoidea in which the anus lies outside the apical system of plates in the posterior interradius. In the members of this Subclass the periproct, including the anus has moved outside the apical system of plates. The periproct has regressed along one particular interambulacrum, namely, AB on the Carpenter Plane, that hereby becomes the posterior. The members of this Subclass comprise irregular sea urchins which are classified by Mortensen into four Orders, two of which are mostly extinct.

The periproct in this Subclass is, in fact, outside the genito-ocular ring in interambulacrum 5. The forms included in this Subclass are characterized by more or less marked bilateral symmetry, secondarily acquired.

Of the four Orders of this Subclass, three, namely, Orders Ccassiduloida, Clypeastroida and Spatangoida are represented by specimens in the Museum collection.

ORDER CASSIDULOIDA

The members of this Order are mostly extinct. The test ranges from round to oval in profile, with the apical system and peristome central or slightly anterior. On the aboral surface, the ambulacra are more or less petaloid, and around the peristome, they typically form phylloides alternating with well developed bourrulets. The periproct varies in its position from a location where it may be contiguous with the apical system to an oral location near the peristome and may be sunk in a groove. In most Cassiduloids, the Aristotle's Lantern disappears during the juvenile stages.

A single species of this Order is represented in the Museum collection, namely, *Echinolampas ovatus*, of the genus *Echinolampas* belonging to the family Echinolampadidae.

Family ECHINOLAMPADIDAE

This family includes Irregular Echinoids which have open petaloids, with this peculiar feature that the two pore rows of each petaloid are of uneven length. The periproct, posteriorly located on the aboral side is covered with three large plates. This family comprises a number of species confined to tropical and subtropical waters, living mostly in waters of moderate depth.

Genus *Echinolampas* Gray.

This genus includes Irregular Sea Urchins of more or less ovoid shape, with the apical system excentric. The petaloid ambulacra are elongate, unequal, the pores of the same petal being often differently developed. The actinal surface (i.e., the oral surface) is slightly concave. The actinostome (i.e., the peristome) is transverse, elliptical or pentagonal, more or less excentric. The floscelle is fairly well marked and the bourrelets are moderately prominent. The anal system is infra-marginal and transverse. The tubercles are of very uniform size, the difference in size being scarcely perceptible between the actinal surface and the rest of the test.

The test is more or less ovoidly elongated, the longitudinal diameter of the test being greater than the transverse diameter. The mouth is anterior. The periproct is situated at or below the ambitus, not in a groove or depression.

This genus is represented in the Museum collection by a single species, *Echinolampas ovata* (*Echinolampas oviformis*) which is a familiar and widely distributed species in the Indo-Pacific Region. Specimens of this species collected from Tuticorin and the Indian Ocean are represented also in the British Museum collections.

Echinolampas ovata (Leske).

FIGURES 40 AND 41.

Echinolampas ovatus, Leske, Add. ad Klön, 1778, p. 127.

Echinus oviformis, Gmelin, Linné, Syst. Nat. Ed. 1788.

Echinolampas oviformis, Gray, Ann. Phil., 1825, p. 7.

Echinolampas oviformis, Agassiz, Al., "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard, VII, 1872—74, pt. III, p. 553

Echinolampas ovata, Meijere, Echinoidea, Siboga-Expeditie, XLIII (—Livr. XIV) 1904, p. 234.

Echinolampas ovata, Döderlein, Valdivia, Echinoidea, 1906, p. 240.

Echinolampas ovata, Clark, H.L., Memoirs of the Museum of Comparative Zoology, Harvard, XLVI, 1917, pl. CLIII, figs. 1 and 2.

Echinolampas ovata, Koehler, Echinoidea, Indian Museum Cassidulidae, 1922, pp. 140—144; pl. VI, fig. 5; pl. XIV, fig. 8.

Echinolampas ovata, Clark, H.L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, London, 1925, p. 184.

Echinolampas ovata, Gravely, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bull. Madras Government Museum. (Natural History), I, No. 1, 1927, p. 171.

Echinolampas ovata, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum, (Natural History), V, No. 1, 1941, pp. 91 and 106.

Echinolampas ovata, Hyman, The Invertebrates, Echinodermata, 1955, p. 532, fig. 229 D.

The test is rather high and inflated at the edges. The outline of the test from above is elliptical. The apex is very excentric and placed anteriorly. The tuberculation on the test is fine and close-set. The apical system is small. The poriferous zones are broad; the poriferous areas of areas I and V are markedly unequal, the outer being longer. The pairs of pores are distant. The petals, especially the posterior pair are

not strictly petaloid in shape. The poriferous zones are diverging. The anterior zones of the anterior pair and the posterior zones of the posterior pair of pttals are much shorter than the other zones of the same petals. The mouth corresponds nearly in position with the position of the apical system. The actinal surface is arched gradually towards the actinostome, and is less concave, except near the actinostome.

The bourreletes are scarcely developed and in old specimens forming a mere thickening of the lip of the actinostome, with phyllodes more or less indistinct. The tuberculation of the actinal surface is coarser than that of the upper part of the test.

This species is fairly widely distributed around the Indian Coast and in the Indian Pacific Region generally. On the East Coast of South India, this species has been recorded from the Madras Beach, Tuticorin and in the Pamban area in the Gulf of Manaar. This species has been recorded from the following localities: Indian Ocean, India, Tuticorin, West Australia, Dampier Archipelago and Lewis Island. Agassiz (*loc. cit.*) records it from the Red Sea and the Moluccas Islands.

Unfortunately, this species is represented in the Museum collection mostly by dry tests, although there are many of them in the collection. In fresh condition, the specimens are rather bright buff in colour.

Specimens in the collection.—Both wet and dry-preserved specimens are represented in the Museum collection, although the majority of the specimens are only dry and empty tests.

I. Reference Collection :

- (i) One wet-preserved specimen. Locality: Tholayirampar, Tuticorin.

The specimen is pale brownish, with a close fur of minute spines all over the surface, but the portions of the surface from which this coat of spines has been eroded appear as creamy white, irregular patches. The test is elongately ovoid, with the mouth at the centre of the lower, flattened, and somewhat concave surface and the anus also on the oral side at the posterior end. The petaloid ambulacra are distinct, the petals being open at their distal extremity and one limb of the petaloid ambulacra being longer than the other usually. The mouth aperture is somewhat broadly pentagonal.

It should be noted that the mouth is always more or less circular or broadly pentagonal in the specimens of this species, but the anus is more or less elongately oval transversely. In the case of anus, therefore, it is only the transverse (longer) diameter that is mentioned in the following measurements of these specimens.

Measurements :

Long diameter of the test: 58 mm.

Short diameter of the test: 49 mm.

Height of the test: 32 mm.

Diameter of the mouth: 4 mm.

Diameter of the anus: 6 mm.

Except the above mentioned specimen, which is wet-preserved, the remaining ones in the collection are all dry-preserved ones. The description is more or less the same as that of the above specimen.

(ii) One small, dry-preserved specimen. Locality: Kundugal Point, Pamban, Gulf of Manaar, 1943. The test is dull chalky white. The pore pairs forming the limbs of the petaloid ambulacra are beautifully distinct, the pores of each pair being connected by a distinct transverse groove or line. The large rectangular plates which make up the test are arranged in regular double rows in the interambulacral areas and are clearly seen in this specimen.

Measurements :

Long diameter of the test: 47 mm.

Short diameter of the test: 41 mm.

Height of the test: 25 mm.

Diameter of the mouth: 4 mm.

Diameter of the anus: 5 mm.

(iii) One dry-preserved specimen, exceptionally broad in proportion to its height and somewhat depressed. Locality: Kundugal Point, Pamban, Gulf of Manaar. 1943.

The test is white, with the grooves of the petaloid ambulacra well depressed.

Measurements :

Long diameter of the test: 59 mm.

Short diameter of the test: 56 mm.

Height of the test: 31 mm.

Diameter of the mouth: 5 mm.

Diameter of the anus: 7 mm.

(iv) Four dry-preserved specimens of which the largest is about 60 mm. long and the smallest 52 mm. long. They are mostly white, but one of them is slightly tinged with pale brown. Locality: Shingle Island, Gulf of Manaar, 1949.

Measurements : Largest specimen :

Long diameter of the test: 60 mm.

Short diameter of the test: 54 mm.

Height of the test: 40 mm.

Diameter of the mouth: 6 mm.

Diameter of the anus: 8 mm.

Smallest specimen :

Long diameter of the test: 52 mm.

Short diameter of the test: 47 mm.

Height of the test: 32 mm.

Diameter of the mouth: 5 mm.

Diameter of the anus: 7 mm.

(v) Twelve dry-preserved specimens. Locality: Pullivasal Island, near Krusadai Island, Gulf of Manaar, 1943.

The specimens in this lot are all dull chalky white and some of them are rather worn out. One specimen (the largest) is tinged with pale brown, while a few others have been dirty pale greyish patches. The specimens (dry tests) range in size from 62 mm. in length to about 48 mm. in length. The actinal surface of the test is rough and granulated in some specimens, but smooth and worn out in others.

Measurements : Largest specimen :

Long diameter of the test: 62 mm.

Short diameter of the test: 55 mm.

Height of the test: 37 mm.

Diameter of the mouth: 5 mm.

(The anal aperture is broken and hence its diameter could not be determined accurately).

Smallest specimen :

- Long diameter of the test : 48 mm.
- Short diameter of the test : 41 mm.
- Height of the test : 30 mm.
- Diameter of the mouth : 4 mm.
- Diameter of the anus : 6 mm.

Four more specimens in this lot are almost of the same size as the above specimen, while the remaining ones are larger, ranging from 52 to 56 mm. in length.

II. Gallery Collection :

(vi) Two dry-preserved specimens exhibited in the Gallery (labelled *Echinolampas oviformis*, which is a synonym for *Echinolampas ovatus*). Locality : Pamban, Gulf of Manaar.

Both specimens are brownish, the largest specimen being darker brown and the smaller one being lighter, yellowish brown. In the larger specimen the apical area bears a slightly abnormal depression which has resulted in the abnormal displacement of two of the petaloid ambulacra.

Measurements : Larger specimen : (This is the largest specimen of this species in the collection).

- Long diameter of the test : 66 mm.
- Short diameter of the test : 57 mm.
- Height of the test : 38 mm.

Smaller specimen :

- Long diameter of the test : 53 mm.
- Short diameter of the test : 47 mm.
- Height of the test : 30 mm.

(Note.—The diameters of the mouth and the anal apertures could not be determined in the two above mentioned gallery specimens as the specimens are firmly glued down on the display board by their oral sides and could not be detached without risk of damage).

ORDER CLYPEASTROIDA

The Clypeastroids include the irregular Echinoids popularly known as the Sand Dollars, Sea Biscuits, etc. The test is usually flattened, oval or rounded or somewhat angled at the ambitus and is often very solid and strongly built with heavy internal skeletal supports. The peristome and apical system are usually central. The latter generally consists of a porous pentagonal plate composed of fused genitals and madreporite, accompanied by very small terminals. On the aboral side, the ambulacra form five well developed petaloids with conjugate pore-pairs; elsewhere, there are large numbers of small, uniporous podia, emerging not only along the ambulacra, but often along the interambulacra also. Phylloides and bourreletes are wanting. The periproct varies in position in the posterior interambulacrum, but is never in contact with the apical system. There are no gills or gill cuts. The test is usually covered densely with small spines. A large Aristotle's Lantern with broad, flattened pyramids is present, but compasses are lacking. Globiferous pedicellariae are usually wanting, but the three other types occur, although not conspicuously. There is a single concealed sphaeridium (sometimes two) along each ambulacrum near the peristome. The Sand Dollars of this Order are classified by Mortensen into five families, of which specimens belonging to three families, namely, the Clypeastridae, the Laganidae and the Scutellidae are represented in the Museum Collection.

Family CLYPEASTRIDAE

This is a well defined family of Irregular Urchins in which the petaloids are formed of primary plates alternating regularly with demiplates. The two pores of each pair are widely separated, connected by a furrow. The ambulacra are much broader than the interambulacra. On the oral side, the ambulacra usually show a simple, central furrow. The apical system is central, consisting of a porous, rounded or pentagonal plate, with five minute terminals and five gonopores placed at the plate angles or removed somewhat from the plate. The periproct, covered with small plates, is found on the oral surface near the posterior margin.

The auricles are separate, each being placed on the ambulacrum; the test is moderately high or flattened, but rarely discoidal. The anus is marginal or inframarginal. The genital pores are five in number.

This family includes but one existing genus, *Clypeaster*, comprising many species in tropical and subtropical waters, living on or buried in, sandy bottom.

Genus *Clypeaster* Lamarck.

This genus includes irregular urchins which are readily distinguished from their allies included in the Order Clypeastroida, by the rather flattened and depressed shape of their tests. The actinal surface (oral surface) is markedly flattened, but the mouth is not conspicuously sunken. The ambulacra radiating from the peristome on the oral surface are fairly well defined. The interior of the test is characterized by the absence of the double ambulacral chamber, and the presence of slender, needle-like pillars which replace the massive columns of the other genera of the Order Clypeastroida. The actinal surface is flat. The actinostome (peristome) is sunken only in a slight cavity and is well circumscribed.

The poriferous areas of the petals are more or less incurved distally; (if this is not well marked, the test is much flattened); the anus is infra-marginal.

This genus is represented in the Museum Collection by two species, which are fairly common on the South Indian shores, namely, *Clypeaster humilis* and *Clypeaster rarispinus*. In the former species, the odd, anterior ambulacrum is specially elongated and the test is not so markedly five-angled and the body not so thin, while in the latter the body is thin and clearly five-angled (pentagonal) in outline, the margin being indented between the rounded angles.

Clypeaster humilis (Leske).

FIGURE 42.

Echinanthus humilis, Leske, 1788, Add ad. Klein, p. 121, pl. xix, figs. A, B.

Clypeaster humilis, Agassiz, Al., "Revision of the Echini", Illustrated Catalogue of the Museum of Comparative Zoology, Harvard; No. VII, 1872-74, Part I, p. 100. Part III, p. 510. Pl. xi a, figs. 1-8.

Clypeaster humilis, Agassiz, Al., Challenger Reports, Echinoidea, p. 119.

Clypeaster humilis, Tenison-Woods, "On the habits of some Australian Echini", Proc. Linn. Soc., N. S. Wales, IV, p. 203.

Scutella placunaria, Lamarck, Hist. Naturelle des animaux sans vertebres, 1816, Paris, 1815-1822.

Echinanthus explanatus, Gray, "New Genera and species of Scutellidae and Echinolampadidae", Proc. Zool. Soc. London, 1851, p. 35.

- Echinanthus explanatus*, Gray, "Catalogue of the Recent Echinida in the British Museum, London, 1855, p. 6, pl. i, fig. 1.
- Echinanthus testudinarius*, Gray, Proc. Zool. Soc. London, 1851, p. 35.
- Echinanthus testudinarius*, Gray, Catalogue of the Recent Echinida in the British Museum, London, 1855, p. 6, pl. i, fig. 1.
- Clypeaster placunarius*, Michelin, Monographie des Clypeastres fossiles, Mem. Soc. Geol. France 2nd Series, t. VII, 1861, Mem. no. 2, p. 135, pl. xxxv, fig. 2a. (non *Clypeaster placunarius* Agassiz et Desor).
- Clypeaster Saisseti*, Michelin, Ibid., 1861, a, p. 328, pl. ix, fig. 2.
- Clypeaster rosaceus*, Loven (Seven), Echinologica, Kongl. Svenska Vetenskaps Akad. Handlingar, Vol. XVIII, 1892, p. 173.
- Alexandria magnifica*, Pfeffer, Die Clypeastriden des Hamburger Museums, Verh. Naturw. Vereins, Hamburg, V, 1881, p. 58.
- Clypeaster humilis*, Duncan, "On the Pergnathic girdle of Echinoidea", Journ. Linn. Soc. London, Zoology, XIX, p. 205.
- Clypeaster humilis*, Bell, Rep. Zool. Collections "Alert", London, 1884, p. 122.
- Clypeaster humilis*, Bell, "Echinoderms from Tuticorin, Madras", Proc. Zool. Soc. London, 1888, p. 384.
- Clypeaster rosaceus*, Loven, "The Linnaean species of Echinoidea", Bih. K. Svensk. Vet. Ak. Handl., XIII, 4, p. 173.
- Clypeaster humilis*, Ramsay, Echinoderms of the Australian Museum, 1885, p. 51.
- Clypeaster humilis*, Andereon, "On some Indian Echinoidea", Journ. Asiatic Soc. Bengal, LXIII, 1894, p. 188.
- Clypeaster humilis*, Sluiter, Die Echiniden-Sammlung des Museums zu Amsterdam, Bijdragen tot de Dierkunde, XVII, 1895, p. 72.
- Clypeaster rosaceus*, Meijere, Siboga-Expeditie, Echinoidea, 1904, p. 133; pl. xviii, figs. 352 and 353.
- Clypeaster humilis*, Brown, (R. N. Rudmose), Echinoidea and Asteroidea from the Mergui Archipelago, Proc. Roy. Soc. Edinburgh, XVIII, 1910, p. 41.
- Clypeaster humilis*, Lambert, "Note sur la synonymie des especes vivantes de Clypeastres", Ann. Soc. Linnaena de Lyon, t. LXI. Lyon, 1914, pp. 13, 18, 19, etc.
- Stolonoclypus humilis*, Lambert et Thiery (P), Essai de Nomenclature raisonne des Echinides, 1909-1914, 5 fascicules, Chaumont, 1914, p. 301.
- Clypeaster humilis*, Clark. H. L., "The Echinoderms of the Western Australian Museum", Records of the Western Australian Museum, I, 1914, p. 36, pl. exxiii, fig. 5.
- Clypeaster humilis*, Koehler, R., "Echinides du Musee Indien a Calcutta, II, Clypeastrides et Cassidulides, Calcutta, 1922, p. 51, pl. fii, fig. 1 to 5 and 12; pl. xiv, fig. 23 and pl. exxxviii, fig. 4.
- Clypeaster humilis*, Clark, H. L., Memoirs of the Museum of Comparative Zoology, Harvard, XLVI, 1914, pls. 137 and 138, fig. 4.

Clypeaster humilis, Clark, H. L., Catalogue of the Recent Sea Urchins (Echinoidea) in the Collection of the British Museum, (Natural History), London, 1925, p. 149.

Clypeaster humilis, Gravelly "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum (Natural History), V, No. 1, part 1, 1941, p. 89 (*Clypeaster* sp.).

The test is low, rather flattened. The margins are thin. The tuberculation is fine. The ridges between the pore-pairs bear a single, regular series of 6-15 primary tubercles. The poriferous areas converge rather abruptly and tend to close the petaloids.

This species is distinguished by its specially elongated, odd, anterior petaloid ambulacrum and the great width of the poriferous zone at the extremity of the petals. The petals are usually closed. The poriferous furrows are crowded at the extremity of the petaloids. They are characterized by their uniform width and somewhat swollen, median tuberculiferous part rising above the poriferous zone. The pores of the poriferous zone are large—larger than in the other species of the genus; the outer pore, especially, is of great size. The genital openings are distant. The tubercles of the upper part of the test are somewhat smaller than in the West Indian species. On the actinal side, the tubercles increase in size towards the actinostome (i.e., the peristome) and become quite large, especially near the median interambulacral space: the space occupied by the miliaries between the primary tubercles is reported to be wider in normal specimens from other localities than in West Indian species. In very large specimens (measuring about 245 mm.), the edge is extremely attenuated; the outline is still more undulating than in smaller specimens, but not pentagonal, as is so frequently the case in the West Indian species. The proportions of the petals in the rosette are not changed in such large specimens. The tuberculation is remarkably uniform on both sides. In very young specimens, the outline tends to be more or less circular, the rosette is short and the ambulacral pores occur in the horizontal sutures above and below. The odd ambulacrum shows a tendency towards elongation even in young specimens.

Koehler (*loc. cit.*, p. 52) reports that one of the characters which strikes immediately when one examines the dorsal surface of *Clypeaster humilis* is the relatively short length of the petaloids and the large interval that separates their very much rounded distal extremity from the corresponding margin of the test. It is well-known that the five petals of *Clypeaster humilis* have a more or less obovate form, and their maximum width is attained at a point beyond half their length. On the other hand, the petals form on the dorsal surface of the test a very appreciable projection and the inter-poriferous zone in particular is more or less strongly convex; the poriferous zones are also very convex. The interporiferous zones are covered with numerous primary granules, closely crowded between which the miliary tubercles occur in less abundant numbers. The poriferous zones bear between the successive pairs of pores, a row of primary tubercles, equally very close-set. The characters presented by the form of the petals and their length in proportion to the width of the test remain almost entirely constant among the specimens of *Clypeaster humilis*.

The pedicellariae of *Clypeaster humilis* are very poorly known. Meijere has observed the tridactyle and the ophicephalous types, but he mentions that they do not have any particular character and he has just represented one valve of an ophicephalous pedicellariae of this species in his illustrations. Koehler (*loc. cit.*, p. 52) had observed, in the specimen he had on hand, two different sets of tridactyle pedicellariae—the trifoliate and the ophicephalous—and he remarks that the tridactyle pedicellariae in particular present certain characters which could be advantageously utilized for establishing the differences between *Clypeaster humilis* and various other species of the genus. The tridactyle pedicellariae of the first form are reported to have a head, large and wide and the valves are 0.8 mm. in length and its length equals a third of the total length. This region is almost as long as the width and its margins are smooth or at most provided

with two or three small denticulations, very low, and scarcely apparent. The apophysis, slightly elevated, has its free border almost completely smooth. The limb at first rather narrow, is progressively widened.

The trifoliate pedicellariae are very abundant. The valves measure 0.10 to 0.12 millimetres in length.

The limb which commences by a short external column, widens very rapidly.

The ophicephalus type of pedicellariae, which are not very plenteous, have already been figured by Meijere; their valves are about 0.15 mm. in length.

The Aristotle's lantern is very well developed. Agassiz Al., (*loc. cit.*) has published several photographs of the entire lantern and also of different isolated pieces.

This species has been recorded from a very wide range localities extending from the Red Sea through the Indo-Pacific Region to Australia. Around the Indian Coast, this species has been recorded specifically from Madras and Tuticorin and from the Pamban area in the Gulf of Manaar.

Some of the localities from which this species has been collected are: Red Sea. Muscat, East of Persian Gulf; Makran Coast between Muscat and Baluchistan, Madras, Tuticorin, Pamban, Gulf of Manaar; Philippine Islands, Amboina (15 to 20 fathoms, Challenger); Queensland, Port Denison (Alert Expedition).

Anderson (*loc. cit.*, p. 194) has recorded that very numerous specimens were obtained off the Coromandel, Malabar and Ceylon Coasts in from 10 to 40 fathoms.

In the Madras Museum collection, this species is represented both by dry and wet-preserved specimens from Madras and Pamban. Clark (*loc. cit.*) states that in the single specimen of this species from Tuticorin in the British Museum Collection which is a bare test, the inter-poriferous areas are rather flat, the unpaired petal widely open and petals 2 and 4 are not closed. He also cites three fine specimens of this species from Madras in the British Museum collection of which largest is reported to measure 130 mm. x 120 mm. x 19 mm. The colour of these specimens is said to be light reddish brown, which is rather unusual for this species. The largest recorded specimen of this species (contained in the British Museum collection) is said to measure 163 mm. x 148 mm. x 24 mm.

Specimens in the collection.—

Reference collection: (i) Two wet-preserved specimens. Locality: Unknown

The specimens are brownish, with a close fur of short, slender, whitish spines which are slightly more profusely developed on the flat oral side and longer, especially around the mouth. The specimens are broadly elongately ovate in outline, somewhat broadened and truncated on the posterior side and somewhat narrowed and rounded towards the anterior side. The five grooves radiating from the mouth on the under side are distinct and the spaces in between these grooves towards the mouth are paler, almost whitish, at least in one of the specimens. The body is flattened, disk-shaped, with the dorsal side rather raised and convex in the region of the petaloid ambulacra. On the dorsal side also the areas enclosed by the petaloid ambulacra are paler.

Measurements: Larger specimen:

Length: 80 mm.

Width: 70 mm.

Height (at the centre): 20 mm.

Smaller specimen:

Length: 71 mm.

Width: 64 mm.

Height (at the centre): 13 mm.

Gallery collection: (ii) One large, dry-preserved specimen exhibited in the Gallery.
Locality: Pamban.

The specimen is brownish with the areas enclosed by the petaloid ambulacra somewhat darker brownish. The large, rectangular plates of the test in regular rows in between and beyond the ambulacral areas are distinctly seen in this specimen as the fur of spines has been lost in this specimen. The entire surface of the test presents a minutely pitted appearance, the pits appearing as small, close-set, neat circles on the plates throughout the surface. The petaloid ambulacra, the pore pairs and the transverse grooves connecting the pores of a pair are distinctly seen in this specimen.

Measurements: Length: 116 mm.
Width: 95 mm.
Height (at the centre): 20 mm.

***Clypeaster rarispinus* (Meijere).**

FIGURE 43.

Alexandria magnifica, Lorient, P. de, "Notes pour servir à l'étude des Echinodermes, 1st Series, fasc. III, Mem. Soc. phys. et Hist. Naturelle, Geneve, Volume supplémentaire, 1891, p. 20.

Clypeaster rarispinus, Meijere, Siboga-Expedition, Echinoidea, 1904, p. 134; pl. vi, figs. 55 and 56; pl. xviii, figs. 354 to 361; pl. xix, fig. 362.

Clypeaster rarispinus, Clark, H.L., "The Echinoderms of the Western Australian Museum", Records of the Western Australian Museum, Vol. I, 1914, p. 30.

Clypeaster rarispinus, Koehler, R., "Echinides du Musée Indien Calcutta, II; Clypeastrides et Cassidulides, Calcutta, 1922; pp. 55-60, pl. v, figs. 1, 2 and 7; pl. vi, figs. 7-11; pl. xiv, fig. 9.

Clypeaster rarispinus, Gravelly, "Shells and Other Animal Remains of the Madras Beach", Bull. Mad. Government Museum, (N.S.), Natural History, V, No. 1, part 1, 1941, p. 90, and p. 106.

The body is thin and clearly 5-angled (pentagonal). Between the rounded angles, the margin is indented; in the posterior inter-radius is the middle part, which also contains the anal field, slightly to the front, so that on either side of it is found an indentation. The body is as long as it is broad; the greatest breadth is in the region of the middle ambulacra. The margin is up to about 4 mm. thick in average adult specimens, slightly swollen, and sometimes not very clear. The middle part of the apical area is strongly conical and this elevation extends up to the tip of the petals. The oral side is flat or slightly concave. The ambulacral grooves are deep and run nearly up to the margin, and often extend to some distance on the apical side.

The buccal field is situated in the centre of the oral side and is small and circular. The anal area is situated on the same side at a distance of slightly less than its length, near the margin. It is slightly broader than long and slightly smaller than the buccal field. In the centrally situated apical field are found five small genital pores; the ocular pores are very minute and not always distinguishable. The primary tubercles are equally large on both sides of the body, and are at a distance from one another, but not so scanty in all specimens. Thus in one specimen, there are in the interambulacral plates on the

apical side, 7-10 of them, in another 12, and up to 20 in the biggest specimen, while in the ambulacra there are 12 to 30. At the margin, these primary tubercles are pushed slightly close to one another. Also in the middle zone of the petals, there are more of them, but not arranged in any regular fashion. Sometimes they appear in the poriferous zone also. The miliary tubercles found in between the primary tubercles are numerous, but they do not touch one another. On either side of the ambulacral grooves, the primary tubercles are densely crowded. The petals are lancet-shaped; they are either broadest at the middle, or a little above the middle. The outer pores are slightly bigger than the inner ones and stretched crosswise.

The ridge between two pore pairs has a row of six to eight small miliary tubercles, sometimes also primary tubercles. In the last case, the surrounding area of the pore pairs are often slightly large in size; in neighbouring pores are pushed close together or the pore pairs are pushed away from each other. The petals are definitely closed at the ends. The middle ones extend up to half the distance to the margin of the body. In their length, the different petals vary very little; it is mostly the unpaired ones that are distinguished by their greater length.

In the body are found 'pillars' (Pfeifer?) characteristic of the genus *Clypeaster*. Firstly, round the mouth field in the inter-radii; these are stronger; then the same type appears at the periphery. The region between has only very thin pillars, like those which appear between the stronger pillars. The latter are flattened. Some are fork-shaped like the letter "Y".

There are five pairs of ambulacral processes; they are triangular and are indented at the top margin.

Koehler (*loc. cit.*, p. 55), refers to an important character which has been noted by Meijere. It is the flattening (depression) of the interporiferous zones of the petals, on arrangement which recalls the condition noted in another allied species, *Clypeaster Annandalei*. In the very numerous specimens of *Clypeaster rarispinus* collected by R.I.M.S. "Investigator", Koehler records that even in the large specimens, the petals follow very closely the general curvature of the body, without forming an appreciable groove, Koehler reports that the test itself is always very much depressed in this species and that its border is always very much thinned out. Its contour is subject to certain minor variations. The petals are narrow and elongated. There does not exist between the successive pairs of pores, any regular rows of primary tubercles. All that one observes is that here and there especially in the external half of the petal, a primary tubercle is closer to the internal border of the poriferous zone than to its external border. The interporiferous zone is narrow and bears primary tubercles of unequal size, scarcely crowded together and very irregularly disposed. The smaller ones are of the size of the tubercles of the poriferous zone, while the others are a little bigger.

The tridactylous pedicellariae are of two types. One type consists of rather large ones, and the length of their head attains 0.40 to 0.45 mm. The limb of the valves in these pedicellariae is stronger on the whole than in the diagram given by Meijere (Figs. 359 and 360) and it carries throughout its length, very fine and close-set denticulations, more numerous and less stronger than those which Meijere has represented.

The ophicephalous pedicellariae are very small and the length of their head does not exceed 0.06 to 0.07 mm.

Finally, there exist the trifoliate pedicellariae which have already been noticed by H.L. Clark, of which the valves are only 0.07 mm. in height. The limb forms an almost semi-circular cuilleron with fine denticulations.

The length of the miliary spines ranges around 0.35 to 0.45 mm. and these spines become progressively wider towards their extremity.

Specimens in the collection.—This species is represented only by a few spirit-preserved specimens in the Reference Collection of the Museum. The body is very strongly flattened and depressed and almost disk-like so that the specimen is a typical "sand dollar". It is much more flattened than the test of *Clypeaster humilis* and lacks the raised, convex, central hump-like elevation characteristic of the latter.

The outline of the body is rather roughly pentagonal with bluntly rounded angles. The petaloid ambulacra are more or less elliptical with their distal end more narrowed and pointed than in the preceding species. The rectangular plates composing the test are much less elongate transversely and are hence shorter and more squarish than in the preceding species. The plates on the oral (actinal side) are almost hexagonal in outline. The oral side is absolutely flattened, and even a little concave towards the centre.

Specimens from two localities, namely, Ratnagiri, Orissa State and from Ennur, Tamil Nadu State, are represented in the collection.

(i) Five wet-preserved specimens in alcohol. Locality: Ratnagiri, Orissa State 1963. These are reported to have been obtained at a depth of 9 fathoms while trawling. The specimens are of a more or less brownish colour, mottled with darker or rusty brown indistinct spots or blotches. The oral surface is paler brown. One specimen is broken towards the edge on one side, while the surface of the largest and smallest specimens is slightly cracked although their edges are entire.

Measurements: Largest specimen:

Diameter of the test: 39 mm.

Thickness of the test: 6 mm.

Smallest specimen:

Diameter of the test: 35 mm.

Thickness of the test: 5 mm.

One of the three remaining specimens in this lot is almost of the same size as the smallest specimen (36 mm. in diameter) while the other two specimens are intermediate in size between the smallest and the largest specimen. On the ventral side, five broad, radiating brownish double bands enclosing narrow white grooves are distinctly seen, diverging from the mouth.

(ii) Three small (probably young) specimens, wet-preserved (in alcohol); Locality: Ennur, purchased from the Fisheries Biological Supply Station. Two of these specimens are whitish, dull greyish, over a wide central, circular area on the upper surface, leaving a clear, pure white or creamy white margin all round, about 4 mm. in width. The third specimen (which is much thinner than the other two) is also somewhat pale greyish white above, but the greyish area is more diffuse and is not so sharply demarcated from the narrow whitish zone towards the border. The oral surface is flattened and whitish with a large, central, circular area tinged greyish and with faint indications of the five radiating grooves from the mouth as feeble, brownish streaks.

All the three specimens in this lot are almost equal in size (and are more or less equal in the diameter of their tests).

Measurements: Diameter of the test: 29 mm.

Thickness of the test

(in the two thicker specimens): 4 mm.

Thickness of the test

(in the thinnest specimen): 3 mm.

Family LAGANIDAE.

The Laganidae include sand dollars of mostly small to moderate size, with a thick-edged, flattened test of circular, ovoid, or angled outline. On the aboral surface, the

ambulacra are distinctly petaloid and the interambulacra terminate between them by one large plate. The apical system is fused into one single pentagonal plate. The periproct is situated on the oral surface, which also bears five simple ambulacral furrows, not reaching the edge of the test. The small (miliary) spines terminate in a crown.

The auricles are fused into a single piece on the interambulacra; the test is seldom discoidal, and though flat, never with marginal slits or lunules; petals more or less perfect; madreporic pores are numerous. In the specimens of species belonging to this family, the connection between the two floors is made by walls running parallel to the edge of the test; well developed buccal tubes are present. The petals are lanceolate; the interambulacra are extremely narrow on the actinal side of the test; ambulacral furrows are straight, and the outline is more or less pentagonal.

The members of this family are typically inhabitants of sandy bottoms in shallow waters in the Indo-West Pacific Region.

This family includes only two existing genera, namely *Laganum*, with five gonopores and madreporic pores sunken in lines or pits; and *Peronella*, with four gonopores and madreporic pores not so sunken. Specimens belonging to both these genera are represented in the Museum collection.

Genus *Laganum* Gray.

This genus includes "sand dollars" (irregular Echini) of large and medium size, with depressed test, subpentagonal, often with swollen edge. Ambulacral petals are lanceolate, closed before reaching the margin, scarcely extending beyond half way between the apex and the margin of the test. The pores are distinctly conjugated. The interambulacra are narrow, especially upon the lower side, which is flat, with simple, broad, shallow, porous ambulacra running a short distance beyond the peristomial star, but not reaching the margin. Supports of the edge are concentric with it, broad and few in number. Not more than two or three parallel rows of walls are present. The primary tubercles are uniformly scattered over the surface, and much less numerous than in the other genera of "sand dollars". The miliaries are more numerous. The teeth are articulated upon a groove in the upper surface of the jaws; the tip of the teeth alone is enamelled and although massive, the jaws are not quite built upon the pattern of the Clypeastroids, but are never like the jaws of the Scutellidae. **The anus is infra-marginal. The outline is more or less pentagonal, angular or rounded anteriorly and truncated posteriorly.**

There are no pillars usually between the jaws and the alimentary canal; five genital openings are present; the upper and lower floors are perfectly smooth; the sutures of the plates of the petals are well seen from the interior. Several of the species of *Laganum* have a superficial resemblance to the flat *Clypeastri*; this has led to considerable confusion between the species of the two genera with *Clypeaster scutiformis* and *Clypeaster humilis*.

The genital pores, five or six in number, are present in all the interambulacra.

Two species of the genus *Laganum*, namely, *Laganum decagonale* and *Laganum depressum* are represented in the Museum collection.

Laganum decagonale (De Blainville).

FIGURE 44.

Scutella decagonalis, De Blainville, Dict. Sci. Nat., Vol. 48, 1827, p. 229.

Laganum decagonum, Agassiz, A., Mon., Echin. Mon. Scut., 1841, p. 112, pl. xxiii, figs. 16—20.

- Laganum decagonale*, Bell, F.J., Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert", 1881-82, British Museum, London, 1884, pp. 122, 130.
- Laganum decagonale*, Agassiz Al., Challenger Reports, Echinoidea, p. 120.
- Laganum decagonale*, Pfeffer, Die Clypeastriden des Hamburger Museums, Verh. naturw. Vereins Hamburg, V, 1881, p. 60.
- Laganum decagonale*, Ramsay, Catalogue of Echinodermata in the Australian Museum, Echini, 1885, p. 52.
- Laganum decagonale*, Bell, Observations of the generic and specific characters of the Laganidae, Annals of Natural History, (5), Vol. XI, p. 130.
- Laganum decagonale*, Döderlein, Seeigeln von Japan und den Liu-Kiu-Inseln, Archiv f. Naturg. Jhg., Bd. 51, 1885, p. 105.
- Laganum decagonale*, Koehler, R., Catalogue Raisonné des Echinodermes recueillies par M. Korotneff aux îles de la Sonde, Mem. Soc. Zool. France, XX, 1895, p. 417.
- Laganum decagonale*, Bedford, "On Echinoderms from Singapore and Malacca", Proc. Zool. Soc. London, 1900, p. 284.
- Laganum decagonale*, Döderlein, Bericht über die v. Semon Gesamm., Echinoidea in SEMON, Zool. Forschungen, V, Jen Denkschr., VIII, 1902, p. 46 (688).
- Laganum decagonale*, Anderson, Report Marine Survey of India, 1898/99, p. 7.
- Laganum (Peronella) decagonale*, Meijere, Siboga-Expeditie, Echinoidea, XLIII, (Liver. 14), 1904, p. 117, pl. vi, figs. 58-62 and pl. xviii, fig. 319-324.
- Laganum decagonale*, Brown, (R.N. Rudmose), Echinoidea from the Kerimba Archipelago, (Mozambique), Ib, XVIII, 1910, p. 42.
- Laganum decagonale*, Brown, (R. N. Rudmose), Echinoidea and Asteroidea from the Mergui Archipelago, Proc. Royal Society, Edinburgh, XVIII, 1910, p. 26.
- Laganum decagonale*, Clark, H.L., "The Echinoids of the Western Australian Museum", Records of the Western Australian Museum, I, 1914, p. 46.
- Jackonaster decagonalis*, Lambert, et Thierry, Essai de nomenclature raisonnée des Echinides, 1914, p. 313.
- Laganum decagonale*, Koehler, R., "An Account of the Echinoidea", Indian Museum, Calcutta, II, Clypeastrides et Cassidulides, 1922, p. 85.
- Laganum decagonale*, Clark, H.L., Catalogue of the Recent Sea Urchins in the Collection of the British Museum, 1925, p. 156.

The test is low; the anus is much nearer the margin than the mouth. The petaloid area is very small. The petals are small, but relatively broad, with curved, poriferous areas, converging to the nearly or completely closed lips. Specimens of larger size often show no indication of the genital pores.

Koehler (*loc. cit.*, 1922, p. 85), records specimens of this species in the Indian Museum collection, collected from Orissa, Ganjam and Vizagapatam Coasts, but he states that the specimens examined by him in general were of small size, the length of the test hardly exceeding 20 mm. Some specimens only are said to be larger, and the largest of them is reported to attain a length of 35 mm.

Laganum decagonale is a well known and widely distributed species, but it has been confused by various authors with *Peronella lesueuri*, and the confusion arose from an error of A. Agassiz who had not distinguished the two species from one another. In his "Revision of the Echini", (*loc. cit.*, p. 148) he unites these two species as synonyms under the name *Peronella decagonalis*.

Laganum decagonale is distinguished by the considerable flattening of the body (test), by the petals being very short, and by the ventral furrows (grooves) being very distinctly marked. It is a species which is very easily recognized. As it is very often confused with *Peronella lesueuri*, it would be perhaps helpful to point out that, apart from the character afforded by the number of the genital orifices, *Laganum decagonale* has the body less elongated. It is often as long as broad, and ordinarily, its contour is polygonal, whilst in *Peronella lesueuri*, the body is always longer than wide, but like the other species, often presenting a polygonal contour. The petals (petaloid areas) are longer than in *Laganum decagonale*.

The characters of *Laganum decagonale*, however, have been clearly indicated by Agassiz in 1841 (*loc. cit.*, p. 112) under the name of *Laganum decagonum* and the species is correctly figured by him (*loc. cit.*, Agassiz, 1841, pl. xxiii. figs. 16-20). More recently, Meijere has defined the external characters of *Laganum decagonale* of which he has described the primary and miliary spines, as well as the pedicellariae. Meijere has mentioned three types of pedicellariae which correspond only to the two known forms of pedicellariae — the tridactyle and the trifoliate. The tridactyle pedicellariae of the first sort have the valves extremely elongated and narrow; they measure about 0.5 mm. in length; the basilar part is very broad and very short. The limb, extremely narrow, is converted almost up to its origin into a groove or duct, which preserves for a greater distance the same length, and widens only at its extremity into a small, short club (cuilleron), carrying a few rather fine teeth at its distal border. It is this form that Meijere has represented in pl. xviii, fig. 321. The tridactyle pedicellariae of the second sort have the limb broader and shorter and the cuilleron elongated and oval, bearing in its second half conical teeth which become stronger and longer as one approaches the extremity. Between the short pedicellariae of which the valves measure only 0.2 to 0.25 millimetres, and the elongated tridactyles of the first type, are noticed numerous intermediate forms. The trifoliate pedicellariae have the valves short and their length measures only 0.08 mm. Their limb widens very rapidly and takes an oval or almost circular form with the teeth very well developed. All the pedicellariae that have been observed in this species possess generally three valves, but sometimes there are only two valves. Ophicephalous pedicellariae are not generally met with in this species.

The shape of the petals is quite constant and characteristic, but the degree to which they are open at the tip shows considerable variation.

This species is found to be widely distributed in the Indo-Pacific Region (i.e., East Indian Region, from China to Australia). It has been recorded from China, Macao, Java, Batavia, Roadstead, Macclesfield Bank, at 35-41 fathoms; Challenger Expedition Stations 219 near Admiralty Islands, 150 fathoms (mud); Arafura Sea, 129 fathoms; 49 fathoms (mud); Torres Strait (28 fathoms).

Specimens in the Collection.—Wet-preserved specimens from Rameswaram are represented in the Museum Collection (both in the Reference Collection and in the exhibited series in the Gallery).

The specimens are circular, disk-like, fairly thick, and with the petaloid ambulacra forming a pretty, star-like pattern on the abactinal surface. The abactinal side is slightly depressed some distance within the border, and again slightly convexly raised over the region of the petaloid ambulacra. The oral side is almost perfectly flattened and bears the usual five grooves radiating from the mouth in the centre. The entire surface is covered with a close fur of minute, short, slender, white spines, which are slightly longer and more profusely developed on the oral side.

The specimens are dull greyish. The abactinal side is darker greyish over a wide, circular central area, leaving a paler, whitish, fairly broad margin all round. The ventral side is more or less uniformly dirty greyish white, but even here, in some specimens, the central area tends to be darker greyish.

(i) Seven wet-preserved specimens, preserved in alcohol, in the Reference Collection. Locality: Rameswaram, Gulf of Manaar.

The specimens range from a tiny young one, measuring barely 15 mm. in diameter to nearly adult ones measuring 30 mm. in diameter.

Measurements:

Largest specimen:

Diameter of the test: 30 mm.

Thickness of the test: 5 mm.

Smallest specimen (young one):

Diameter of the test: 15 mm.

Thickness of the test: 3 mm.

Most of the specimens approach very closely in size to the largest specimen.

(ii) Two wet-preserved specimens exhibited in the Gallery. Locality: Rameswaram, Gulf of Manaar.

The specimens are more or less of the same colour and dimensions and approach very closely the largest adult specimen of this species in the Reference Collection noted above.

Measurements:

Diameter of the test: 29 mm.

Thickness of the test: 5 mm.

Laganum depressum (Lesson).

FIGURE 45.

Laganum depressum, Lesson, in Agassiz L., Monographies d'Echinodermes, II, 1841, Monographie des Scutelles, Neuchatel, p. 110, pl. xxiii, figs. 1—7.

Laganum ellipticum, Agassiz L., *ibid*, p. 111, pl. xxiii, figs. 1—7.

Laganum depressum, Agassiz, Al., "Revision of the Echini", Illustrated Catalogue of the Museum of Comparative Zoology, VII; Cambridge, 1872—1874, p. 518; pl. xiii f, figs. 5—8, pl. xxxiii, figs. 3—4.

Laganum depressum, Loriol, P. de, Catalogue Raisonne des Echinodermes recueillies par Robillard a l'ile Maurice, Echinides, Ib, 1883, pl. xxviii, No. 8, p. 37, pl. v, fig. 1.

- Laganum depressum*, Duncan and Sladen, "Report of the Echinoidea of the Mergui Archipelago", Journ. Linn. Soc. London Zoology, XXI, 1888, p. 318.
- Laganum depressum*, Bedford, "On Echinoderms from Singapore and Malacca", Proc. Zool. Soc. London, 1900, p. 283.
- Laganum depressum*, Agassiz, Al., Challenger Reports, Echinoidea, p. 120.
- Laganum depressum*, Tenison-Woods, "The Echini of Australia", Proc. Linn. Soc. N.S. Wales, II, 1878, p. 170.
- Laganum depressum*, Tenison-Woods, "On some new Australian Echini", Ibid., IV, 1880, p. 290.
- Laganum depressum*, Pfeffer, Die Clypeastriden des Hamburger Museums, Verh. naturw., Veriens Hamburg, V, 1881, p. 59.
- Laganum depressum*, Duncan, "On the Perignathic Girdle of Echinoidea", Journ. Linn. Soc. London, XIX, p. 207.
- Laganum depressum*, Ludwig, Echinodermen des Sansibargebietes, Abh. Senckenb. Naturw. Gesellsch., XXI, p. 555.
- Laganum depressum*, Sluiter, Die Echiniden-Sammlung des Museums zu Amsterdam, Bijdragen tot de Dierkunde, XVII, 1895, p. 72.
- Laganum depressum*, Anderson, "On some Indian Echinoidea" Journ. Asiatic Soc. Bengal, LXVIII, 1894, p. 188.
- Laganum depressum*, Anderson, Report of the Marine Survey, India, 1898-99, p. 11.
- Laganum depressum*, Bell, Fauna and Flora of the Maldives and Laccadive Archipelago, Actig. Echinoid, p. 232.
- Laganum depressum*, Meijere, Siboga-Expeditie, Echinoidea, XLIII, (Livr. 14), 1904 p. 114; pl. vi, fig. 57; pl. xviii, figs. 317 and 318.
- Laganum depressum*, Brown, (R. N. Rudmose), "Echinoidea and Asteroidea from the Mergui Archipelago", Proc. Roy. Soc. Edinburgh, XVIII, 1910, p. 26.
- Laganum depressum*, Brown, (R. N. Rudmose), "Echinoidea from the Karimba Archipelago (Mozambique)", I b, XVIII, 1910, p. 42.
- Laganum depressum*, Clark, H.L., "The Echinoderms of Ceylon, other than Holothurians", Spolia Zeylanica, X, 1915, p. 91.
- Jacksonaster conchatus*, Lambert et Thiery, Essai de Nomenclature raisonnee des Echinides, 1914, p. 313.
- Laganum depressum*, Koehler, R., "An Account of the Echinoidea", Indian Museum, Calcutta, II, Clypeastrides et Cassidulides, 1922, p. 88.
- Laganum depressum*, Clark, H.L., Catalogue of the Recent Sea Urchins in the collection of the British Museum, London, 1925, p. 157.
- Laganum depressum*, Clark, A. H., "Echinoderms from the Marshall Islands", Proc. United States National Museum, Vol. 102, 1952, p. 276.

The test is rather flattened with a more or less pentagonal outline at the ambitus. Its length is usually decidedly greater than its breadth; the petaloid area is rather large, its length being 0.60 or more of the length of the entire test.

The edge of the test is rather thin, not swollen. The anus is nearer the posterior edge, and is transversely elliptical or circular. The apical system is larger. The tuberculation is small and crowded on the abactinal side; on the actinal side, the tubercles are larger, more distinct, especially in the slightly depressed interambulacral spaces; where they are so far apart as to form fan-shaped areas, extending from the actinostome (peristome) to the edge, where the tubercles are more distinct than in the adjoining portion of the actinal surface. The ambulacral furrows are broad, extending nearly to the edge of the test. The peristomial star is distinct. The spines of the abactinal side are similar to those of the actinal side, longer, more slender and more distinctly fluted. Seen from the interior, the concentric walls of the edge of the test occupy a relatively broad space. The jaws are powerful and high; the two posterior jaws are much larger than the anterior ones; the odd jaw is by far the smallest. In small specimens with a longitudinal diameter of about 27 mm., the petals extend rather close to the edge. In older specimens, measuring about 75 mm in longitudinal diameter, the outline becomes more angular, with re-entering sides. The petals extend but a short distance beyond half way between the apex and the edge of the test. In these large specimens, the anus becomes more circular. In spirit-preserved specimens, the colour of the test is usually of a dirty yellow colour.

The greatest transverse diameter of the test is placed behind the anterior pair of ambulacra in old specimens, while it is directly across the tip of the same in smaller specimens. The difference between the longitudinal and transverse diameter becomes less with diminishing size.

The pairs of pores are more widely separated as they approach the tip of the petals, where they are quite distinct. The grooves connecting them become obliterated with age.

As in the case of *Laganum decagonale*, specimens of considerable size often lack genital pores. The thickness of the test and its colour shows considerable variation. Sometimes the spines are unusually long, and form a conspicuous fringe on the margin, making the oral surface unusually soft, with its dense coat of relatively long, slender spines. Specimens of this species are usually olive yellow or light yellowish brown in colour. Large specimens attain a thickness of about 5 mm. at the margin. Such stout specimens have been collected from the Gulf of Manaar area. One of the specimens, reported to have been collected from the Gulf of Manaar and represented in the British Museum collection is said to measure 46 mm. x 40 mm. with a margin 5 mm. thick.

The contour of the test is ordinarily polygonal and more particularly pentagonal with a posterior margin well marked, straight, and often slightly excavated, and the angles rounded or slightly truncated.

The longer primary spines on the ventral surface measure about 1.5 to 1.8 mm. in length. They are fine, pointed and smooth; those on the dorsal surface are very much shorter and their length varies between 0.35 mm. and 0.45 mm. They are very thick, and slightly widened in their second half and finally terminate in a more narrow, rounded extremity. The primary spines of this species which Koehler had observed in the Indian Museum specimens are reported to have their margins almost smooth. The few denticulations which are present in the enlarged part are very low and much less strongly developed than in the spines of the Siboga Expedition specimens reported by Meijere (*loc. cit.* p. 114). These denticulations, however, are very well developed and normally very closely crooked on the miliary spines.

The pedicellariae belong to the three ordinary types, namely, the tridactyle, bifoliate and the ophicephalous types; and the tridactyle pedicellariae are, as usual, of two sorts. In the larger ones, the head is elongated, and measures, on

an average, 0.25 millimetres; the valves are very thin and slender, their basilar part being extremely short, but wide. The limb remains narrow for the greater part of its length. It presents at first the form of a tube, then it gets converted into a very narrow groove or channel which only widens in its terminal quarter forming a palette (or plate) armed with rather strong, conical teeth, and which becomes large in size as one approaches the extremity. These valves are especially constituted by a hyaline tissue and the perforations are extremely reduced; they only form two longitudinal rows, and are not present on the tubular part of the limb, and disappear on the widened part before reaching the extremity.

The tridactyle pedicellariae of the second type, which are often didactyle, have the valves shorter; the limb which is very narrow at its origin rapidly widens into a convex club, almost twice as long as wide, oval, with the extremity rounded, and carrying throughout its length strong teeth and spaces of which the larger ones increase from the base to the extremity of the club. The trofoliate pedicellariae ordinarily present only two valves. These measure 0.08 mm. in length and resemble exactly those of *Laganum decagonale*. The ophicephalous pedicellariae have rather variable dimensions, their head measuring, on an average, 0.18 millimetres in length and 0.08 millimetres in width. The limb carries very strong teeth on its terminal border.

Specimens in the collection.—Two dry-preserved specimens, exhibited in the Gallery, are represented in the Museum collection. Locality: Pamban, Gulf of Manaar.

The specimens are almost uniformly brownish, larger and thicker than the specimens of the preceding species. The test has a more or less indistinctly pentagonal outline and is somewhat elongately ovate, the anterior end being rather narrowly rounded and the posterior end broad and truncated. The petaloid ambulacra are large and occupy a comparatively larger area than in the preceding species. The central area of the aboral side is somewhat more strongly convexly raised and humped than in the preceding species, and between this raised area and the edge, the surface is rather depressed concavely. One of the specimens is covered with a close fur of minute, whitish slender spines all over, while in the other specimen in which the coat of spines has dropped off, the surface is more or less smooth, presenting a minutely pitted appearance under the lens and the petaloid ambulacra are also distinctly seen.

Measurements :

Specimen in which the coat of fur of spines is intact :

Length of the test : 46 mm.

Width of the test : 42 mm.

Thickness of the test at the border : 5 mm.

Thickness of the test at the centre (including the central hump) :

Thickness of the test at the centre
(including the central hump) : 9 mm.

Smooth specimen (without the coat of spines) :

Length of the test : 43 mm.

Width of the test : 39 mm.

Thickness of the test at the border : 5 mm.

Thickness of the test at the centre
(including the central hump) : 8 mm.

NOTE.—The ventral (oral) side is almost perfectly flattened, but as both the specimens are firmly glued down on the display board by their oral (actinal) side, no observation of this aspect of the tests could be made in these two specimens, in view of the risk of damage involved in detaching them from the boards.

Genus *Peronella* Gray.

This genus closely resembles *Laganum* and is related to it, but may be distinguished from the latter by the presence of four genital pores only. It is wanting in interambulacrum 5. Agassiz (*loc. cit.*, "Revision of the Echini", 1872-74, p. 580) is inclined to treat this as a subgenus under *Laganum*, and distinguishes it from *Laganum* s. str. by certain internal characters of the test. In *Peronella*, the partitions forming the connecting walls between the upper and lower floors of the test ramify somewhat as they do in *Scutella* and *Arachnoides*, and extend more than half way to the centre of the test from the edge, instead of forming a narrow belt of three or four concentric simple walls near the edge.

Only one definitely identified species of *Peronella*, namely, *Peronella lesueuri*, is represented in the Museum collection. A specimen belonging to another species of *Peronella* is also represented in the Museum collection, but this is as yet not quite positively determined; however, from a close examination of the specimen, it appears that it might belong to the species *Peronella orbicularis*, and hence it has been tentatively identified as such and reported in the present account.

Peronella lesueuri (L. Agassiz).

FIGURE 46.

- Scutella decagonalis*, Lesson, 1827 in BL., Dict. Sc. Nat. Scut., p. 229.
- Laganum lesueuri*, Agassiz L., Monographies d'Echinodermes, II, Monographie des Scutelles, Neuchatel, 1841, p. 116, pl. xxiv, figs. 3-6.
- Laganum elongatum*, Agassiz, L., 1841, Ibid., p. 117, pl. xxiv, figs. 1-2.
- Laganum rostratum*, Agassiz, L., 1841, Ibid., p. 118, pl. xxv.
- Peronella decagonalis*, Agassiz, Al., "Revision of the Echini", Illustrated Catalogue of the Museum of Comparative Zoology, VII, Cambridge, 1872-74, p. 520: pl. xiii e, figs. 8-11, and pl. xxxvii, fig. 3.
- Peronella Lesueuri*, Agassiz, Al., Ibid., pt. I, 1872, p. 148.
- Laganum elegans*, Pfeffer, Die Clypeastriden des Hamburger Museum, Verh. Naturw. Vereins, Hamburg, 1881, p. 63, pl. i, fig. 4.
- Peronella decagonalis*, Var. pallida, Pfeffer, Ibid., 1881, p. 60.
- Laganum Lesueuri*, Meijere, Siboga-Expeditie, Echinoidea, XLIII, (Livr. 14), 1904, p. 122, pl. vi. figs. 63, 67 and 70, and pl. xviii, fig. 329-333.
- Peronella Lesueuri*, Clerk, H.L., "The Echinoderms of the Western Australian Museum" Records of the Western Australian Museum, I, 1914, p. 53, pl. cxxiv, figs. 23-24.
- Peronella aphanostina*, Clerk, H.L. Mem. Mus. Comp. Zool., XLVI, 1914, p. 168, pl. xxiv.
- Rumphia Lesueuri*, Lambert et Thiery, Essai de Nomenclature raisonne des Echinides, 1914, p. 313.
- Peronella Lesueuri*, Clark, H.L., Report on the Sea Lilies, Starfishes, Brittle Stars and Sea Urchins obtained by the F.I.S. "Endeavour", Commonwealth of Australian Fisheries, Vol. IV, part 1, Sydney, 1916, p. 120.

Peronella Lesueurii, Mortensen, Results of Dr. Mjobergs, Swedish Scientific Expedition to Australia, 1910—1913, XXI, Echinoidea Kongl. Svenska, Vet. Ak. Handlingar, Bd. LVIII, No. 9, 1918, p. 14, pl. v, fig. 25.

Peronella Lesueurii, Koehler, R., "An Account of the Echinoidea", Indian Museum, Calcutta, II, Clypeastrides et Cassidulides, 1922, p. 110.

Peronella lesueurii, Clark, H.L., Catalogue of the Recent Sea Urchins in the collection of the British Museum, London, 1925, p. 159.

This species is described by Agassiz in his Revision of the Echini (*loc. cit.*, 1872-74, p. 520) under the synonymous name, *Peronella decagonalis*. This is said to be the largest and most elegant of the existing species of Laganidae. The test is very much flattened, and distinctly longer than wide. The margins are thin, scarcely swollen, with a slight depression between the edge of the central portion of the test, as in the Laganidae generally. The central part of the test rises somewhat abruptly at the extremity of the petals, and is regularly arched, but only rises to a moderate height even in the largest specimens. The outline of the test is regularly decagonal; the test is bounded by ten truncated sides, the longer sides corresponding to the interambulacral and the shorter to the ambulacral areas.

The petals are usually narrow, and more or less nearly closed. The petaloid area is about half the length of the test or more. The greatest width of the test is anterior to the anterior pair of petals. The interporiferous zone is broad; the poriferous furrows are closely packed, diminishing very gradually towards the extremity, where the poriferous zones converge slightly from the apical system towards the extremity, and are not rounded along the sides of the petals. The anterior petal is somewhat larger than the lateral petals.

There are four genital openings. The actinal surface (i.e., the oral surface) is perfectly flat. That actinostome (peristome) is central, circular, with distinct ambulacral furrows extending nearly to the edge. The interambulacral areas on the lower surface form narrow, well defined bands. The anus is near the edge, elliptical, but placed obliquely to the longitudinal axis. The anus is 0.15 to 0.30 of the length of the long radius from the margin. The tuberculation of both the surfaces is remarkably uniform, but as in all the Laganidae, it is much larger on the lower surface. The spines of the upper surface are small and slender, while those on the lower surface are much larger and stouter; they are distinctly fluted, with minute serrations along the edge.

Larger and smaller specimens of this species are not appreciably different from each other. The pillars of the edge of the test are proportionately as fully developed in the young as in the older specimens. The proportions of the petals are not different, although the decagonal outline of the test is not quite so distinctly marked in young specimens. The colour of the dried specimen is usually yellowish brown, but living specimens are said to be of a brilliant red colour; but there seems to be some variation in colour as some specimens are reported to be pale greyish purple while a specimen taken by the "Alert" Expedition is very dark.

This is the largest of the Laganidae, and specimens often reach a length of 100 to 150 mm. The genital pores seldom make their appearance before the specimen attains a length of 30-40 mm. The test is variable in its thickness, but as a rule, the margin is thin. The shape of the test also shows considerable diversity, but usually, the width is not more than nine-tenths of the length.

In large specimens, the petals are elongated, very narrow and relatively only slightly widened in the middle region; on the contrary, in the young specimens, the petals are definitely lanceolate, widened at their base or almost near the base, and they get narrowed progressively and regularly up to their extremity which is pointed.

A few differences in the dimensions of the periproct can also be noted in the young and in the adult specimens; the periproct is relatively larger in the former, but it never attains the considerable dimensions which are observed in other species such as *Peronella macroproctes* and *Peronella rullandi*.

The test is very slightly raised, and the margins are thin and rather depressed; the dorsal surface presents always, towards the periphery, a border rather wide and well marked, even in small individuals. Seen in profile, the test diminishes progressively in height up to a certain distance from the border and proceeding from this point the height does not diminish up to the margins themselves.

Meijere (*loc. cit.*, p. 122) has already indicated the characters of the primary and miliary spines in this species. The pedicellariae belong, as usual, to the three types, namely, the tridactyle, trifoliate and ophicephalous types. The tridactyle pedicellariae have the head sometimes elongated and sometimes shortened. The valves of the tridactyle pedicellariae with elongated heads measure 0.15 to 0.2 millimetres in length; the limb, which is narrow, remains tubular for three-fourths of its length, but it widens in its terminal part into a small club armed on its margins with strong and elongated teeth. These pedicellariae have been figured by H. L. Clark. Mortensen has represented one in which the valves are thinner. The valves of the small tridactyle pedicellariae measure 0.10 to 0.12 millimetres; their limb widens progressively and rapidly into an oval club, rather broad, armed with strong teeth which become larger in size as one approaches the extremity; the perforations, few in number, form especially a regular row on each side of the median line of the limb. The trifoliate and the ophicephalous pedicellariae do not present any special characteristics.

The internal calcareous partitions which attain a great development in this species, occupy a large part of the general cavity.

There are many species of *Peronella* closely allied to the present one and likely to be confused with it. Among the species of *Peronella* which one may confound with *Peronella lesueuri*, there are forms which have the genital orifices more or less far removed from the apical plate such as *P. peronii* and *P. stellata* L. Agassiz, as well as those in which the periproct is more removed from the posterior border of the test than in *P. lesueuri* (*P. analis*, Meijere, *P. minuta* Meijere, *P. pellucida* Döderlein and *P. rubra* Döderlein). Among those in which the periproct occupies almost the same situation as in *P. lesueuri*, mention may be made of *P. orbicularis* (Leske) and *P. strigata* Agassiz and Clark. Of these, *P. orbicularis* is distinguished by the margin of the test being very thick and *P. strigata* Agassiz and Clark, by the plates being very short.

Peronella lesueuri is said to be widely distributed throughout the extent of the Indo-Pacific Region. It has been recorded from the Seas of China and Japan in the Bay of Bengal and from the following localities: Singapore, Hongkong, Philippines, Ceylon; on the Coast of Australia and New Zealand New Caledonia, Zanzibar, West of Torres Straits (in mud, Challenger Expedition); Queensland and Port Dension, 4 fathoms (H. M. S. "Alert" Expedition).

Specimens in the collection: Ten wet-preserved specimens in alcohol are represented in the Reference Collection of the Museum. Locality: Kilakarai, Ramanathapuram District.

Of the ten specimens four are fairly large, and almost adult (about 34 to 43 mm. in diameter), and six are small and not fully grown ones (ranging from 16 mm. to 28 mm. in diameter). Of these latter specimens, one is incomplete and broken while three others have their central parts missing, so that they are in the form of rings. Only the remaining two among the smaller specimens are entire but even among these two, one (the smaller one) has the central part of the lower (actinal surface) cut away. The four

larger specimens, however, are all entire. Presumably, among the smaller specimens, those with the central portions cut away had been dissected previously for study of the internal parts.

The specimens are somewhat variable in colour. Mostly, they are dull-coloured, dirty greyish white or pale greyish brown; some are paler, while others are darker brown. The largest specimen is more or less dark brownish. There is no marked difference in colour between the oral and aboral sides. The specimens are covered by a close, fine fur of short, slender, minute white spines which are closely crowded together throughout the entire surface. The outlines of the petaloid ambulacra are more or less straight-sided (more markedly so in the adult, full grown specimens) so that they present a pattern more or less resembling the profile of a straight-armed starfish. The outline of the test is more or less circular, but in the largest specimen, it tends to be more or less indistinctly pentagonal, the anterior side being bluntly and broadly rounded and the posterior side broadly truncated. The spines on the oral (actinal) surface appear to be longer. The central part of the abactinal surface is slightly convexly raised into a hump-like thickening.

Measurements:

Largest specimen: (Colour: dark brown).

Length of the test: 42 mm.

Width of the test: 36 mm.

Height of the test (at the centre): 9 mm.

Thickness of the test (at the edge): 5 mm.

Smallest specimen: (Colour: dull whitish).

Length of the test: 24 mm.

Width of the test: 21 mm.

Thickness of the test (at the centre): 4 mm.

Thickness of the test (at the edge): 2 mm.

An unidentified specimen of *Peronella* contained in the Museum collection is very similar to *Peronella lesueuri* and seems closely allied to it; from a close examination of the specimen, it appears that the specimen belongs to the species *Peronella orbicularis* and has hence tentatively been identified as *Peronella orbicularis* (Leske).

Peronella orbicularis (Leske).

FIGURE 47.

Echinodiscus orbicularis, Leske, 1778, Klein Add., p. 144.

Peronella orbicularis, Agassiz, Al. "Revision of the Echini", pt. I, p. 149.

Peronella orbicularis, Agassiz, Al., "Revision of the Echini", pt. III, p. 521.

Laganum orbiculare, Bell, "Penguin", Echinoidea, Proc. Zool. Soc. London, 1894, p. 412.

Laganum orbiculare, Meijere, Siboga-Expeditie, Echinoida, XLIII, (Livr. 14), 1904, p. 126.

Peronella orbicularis, Clark, H.L., Catalogue of the Recent Sea Urchins in the Collection of the British Museum (Natural History), London, 1925, p. 160.

The test is rather stout, the margin being somewhat thickened, about 0.12 of the test length in thickness; the petaloid area is rather large, being 0.60 or more of the total length of the test. The periproct is 0.15 to 0.30 of the long radius from the margin. The petals are almost completely closed.

Al Agasiz (*loc. cit.*) is of the opinion that this might prove to be a young one of *Peronella decagonalis*, but the characters are sufficiently distinct to warrant its being treated as a separate species.

This species also closely resembles *Peronella lesueuri*, but although the differences between this species and *Peronella lesueuri* are not very well marked, they seem to be very constant, and adult specimens are usually distinguishable with ease.

This species is distinguished from *Laganum decagonalis* by the broader and more rounded outline of the test, the shorter petaloid areas, the more swollen edge and the thicker and shorter radiating walls and pillars in the interior of the test.

The outline of the test is nearly circular, the edge of the test being slightly swollen; the abactinal surface is slightly depressed at the extremity of the petals, where the test is covered by large, glassy tubercles.

The petaloid ambulacra are broadly lanceolate, extending more than half way to the edge; the anterior pair are slightly shorter than the others; the poriferous zone is narrow and the poriferous grooves are sharply incised. The poriferous zone is broadest near the extremity of the petals. Four genital pores are present, rather widely separated. The anus (periproct) is transversely elliptical, placed about three times its diameter from the edge of the test. The actinal (oral) surface is quite flattened. The ambulacral furrows are indistinct, extending only a short distance from the actinostome (peristome).

H.L. Clark (*loc. cit.*, p. 160) reports considerable variation in the colour of this species in life; some are pretty red-orange while others are rosy red or brick red. Probably the colour in life is red, of some shade; possibly, this is another point in which *Peronella orbicularis* differs from *Peronella lesueuri*.

The present single specimen in the Museum collection, although bleached and faded due to long preservation in alcohol, yet retains a characteristic pale pinkish tinge, especially over the swollen marginal region of the test.

This species has been recorded from a wide range of localities, including Philippine Islands, Australia, Torres Strait, Cape York, Albany Islands, New Holland, Formosa and Burma; Gulf of Martaban and Macclesfield Bank.

Specimens in the Museum collection: A single specimen, preserved in alcohol, is represented in the Reference collection of the Museum. Locality: Rameswaram, Gulf of Manaar.

The specimen is almost faded into white, but retains a reddish tinge over the greater part of the peripheral areas of the test, especially over the swollen marginal region on the aboral side. The petaloid ambulacra are broadly lanceolate. The fur of spines has been lost, and the entire surface presents a closely pitted appearance under the lens, the small circular pits representing the surface of attachment of the spines. The ambulacral furrows on the flattened ventral surface are quite indistinct and do not extend up to the margin.

Measurements:

Length of the test: 31 mm.

Width of the test: 29 mm.

Thickness of the test (at the centre): 5 mm.

Thickness of the test (at the edge; i.e., the swollen marginal region): 4 mm.

Family SCUTELLIDAE.

This family includes flattened, irregular Echinoids comprising the typical "sand dollars" and "sea biscuits". These are relatively large forms with a very much flattened, thin-edged, discoidal test, provided with distinct petaloids aborally and branched grooves orally. The interambulacra are generally discontinuous on the oral surface and terminate aborally with two small plates. Genitals and madreporic plate are fused into one pentagonal plate with four or five gonopores, whereas the terminals remain more or less separate. The tips of the miliary spines of the aboral side are usually encased in a bag of glandular tissue. Pedicellariae are mostly scarce and the tridentate and triphyllous types are reduced to the small, two valved condition.

The test is flat, usually discoidal, often with lunules or marginal slits. The auricles are fused into a single piece situated on the interambulacrum; ambulacral furrows of the oral side are distinct, at least the posterior reaching the margin.

In this family, the test is reduced to its maximum flatness among Clypeastroids. The outline is more or less circular, and is, unlike the Euclypeastridae, frequently perforated or cut at the margin, so as to form either ambulacral or interambulacral slits or lunules. The ambulacral furrows of the actinal (i.e., oral) side are more or less branching and anastomose, spreading over the interambulacral spaces. The connection between the upper and lower floors is made by partitions, radiating fan-wise from single points. The tubercles of the two sides of the test, as well as the spines which they carry, differ greatly in size. The absence of rotulae is a characteristic feature of the jaws of the Scutellidae; they are extremely flat in some genera, articulating directly upon very low auricles, and the teeth are horizontal instead of being vertical as in Euclypeastridae.

This family is represented in the Museum collection by two species (one of which comprises two races) belonging to the genus *Echinodiscus*.

Genus *Echinodiscus* Leske.

The test is very much flattened; only two lunules or marginal slits are present, and these are placed one in each posterior ambulacrum.

The test in this genus is more depressed than in any other genus of the Scutellidae; the test is thin. The anterior edge is rounded and the posterior edge truncated. There are two lunules or slits (cuts) corresponding to the two posterior ambulacra. Ambulacral plates are small, well defined. Four genital pores are present. The lower surface is flat, and the ambulacral furrows ramify but little towards the exterior edge. The anus is nearer the posterior edge than the actinostome (peristome).

The greater part of the interior of the test is occupied by a calcareous network rising into pillars for more than half the distance between the edge and the actinostome (peristome), leaving the central part more or less filled by a delicate tracery of calcareous cells into which the appendages of the alimentary canal are received.

The jaws, which are extremely flat, articulate upon the auricle, which fits in a pit in the middle of the lower surface of the jaw, and are not enclosed by them, as in other Scutellidae. The spines are uniform in structure, but those of the upper surface are only shorter and slightly clavate.

This genus is represented in the Museum collection by two species, *Echinodiscus auritus* and *Echinodiscus bisperforatus*, both of which are well known species, widely distributed in the Indo-Pacific Region. Both are represented in the Museum collection by specimens collected from in and around the Madras Beach and also from Covelong and from the Kutikal Channel in the Gulf of Manaar area.

Echinodiscus bisperforatus is distinguished from *Echinodiscus auritus* by the test being much thicker, its outline being irregular, narrower anteriorly, rounded and slightly indented opposite the anterior lateral ambulacra and by the lunules being very long and narrow. Further, in *Echinodiscus auritus*, the test is often longer than wide and the Posterior ambulacra each bears a deep, narrow, marginal slit, while in *Echinodiscus bisperforatus*, the test is wider than long, and each posterior ambulacrum bears a long, narrow lunule (i.e., a closed cut, instead of being open marginal slits).

Echinodiscus auritus (Leske).

FIGURE 48.

- Echinodiscus auritus*, Leske, (N.G.), Addimenta ad Kleinii naturalem dispositionem Echinodermatum, 1778, p. 202.
- Lobophora aurita* et *L. bifissa*, Agassiz, L., Monographies d Echinodermes, II, Monographie des Scutelles Neuchatel, 1841, pp. 67 and 70, pl. xiii and xiv.
- Echinodiscus auritus*, Agassiz, Al., "Revision of the Echini", Illustrated Catalogue of the Museum of Comparative Zoology, VII, 1872-74, p. 531, pl. xi a, figs. 9-13, and pl. xiii c, figs. 1-3,
- Echinodiscus auritus*, de Loriol, Echinodermes de l' ile Maurice, Mem. Soc. de Phys. et d' hist. nat. Geneve, XXVIII, 1883, No. 8, p. 36.
- Echinodiscus auritus*, de Loriol, Echinodermes de la baie d' Amboine, Revue Suisse de Zoologie, I, 1893, p. 375.
- Echinodiscus auritus*, Bell, "Additions to the Echinoderm fauna of the Bay of Bengal" Proo. Zool. Soc. London, 1889, p. 7.
- Echinodiscus auritus*, Meissner, Ueber die von Dr. Sander heimgebrachten, Seeigal, Sitzb. Ges., Naturf. Freunde, Berlin, 1892, p. 184.
- Echinodiscus auritus*, Sluiter, Die Echiniden-Sammlung des. Museums zu Amsterdam, Bijdragen tot de Dierkunde, XVII, 1895, p. 72.
- Echinodiscus auritus*, Ludwig, Echinodermen des Sansibargebietes (Ges von Voeltzkow), Adhandl., Senckenb. Naturf. Gesellsch, XXI, p. 555.
- Echinodiscus auritus*, Döderlein, Bericht über die von Semon bei Amboina und Thursday Island gesammelten, Echinoidea, SEMON, Zool. Forschungsr., V, Jan. Denkschr. VIII, 1902, p. 80 (722).
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- Echinodiscus auritus*, Meijere, Siboga-Expeditie, Echinoidea, 1904, p. 138, pl. xix, fig. 366 - 368.
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- Echinodiscus auritus*, Southwell, T., "Notes on the genera *Margaritifera* and *Ayiculidae*, and on post-mortem colour changes in Echinoidea," Ceylon Marine Biological Reports, No. 5, 1911, p. 208.
- Echinodiscus auritus*, Clark, H.L., "The Echinoderms of the Western Australian Museum" Records of the Western Australian Museum, I, 1914, p. 71, pl. cxv, figs. 9-10.
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- Echinodiscus auritus*, Koehler, R., An Account of the Echinoi. der, Indian Museum, Calcutta II, Clypeastrides et Cassidulides, 1922, p. 123, pl. iv, fig. 9; pl. x, fig. 14; pl. xi figs. 5 and 6; pl. xv, fig. 12.
- Echinodiscus auritus*, Clark, H.L., Catalogue of the Recent Sea Urchins in the collection of the British Museum (Natural History), London, 1925, p. 169.
- Echinodiscus auritus*, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Govt. Mus. (Nat. Hist.) V, No. 1, 1941, p. 90.

This is the largest and perhaps the commonest species of the genus *Echinodiscus*. This species is readily distinguished by the posterior ambulacra being each perforated by a deep, narrow marginal slit. The test is depressed, rounded anteriorly and is longer than wide. The greatest width is about half way between the apex and the posterior edge; the anterior extremity is much narrower than the broadly rounded and truncated posterior extremity. The vartex is somewhat anterior and corresponds with the apex. The petals are small, compared to the size of the test, and do not increase appreciably in size in proportion to the increase in size of the test. The genital pores, four in number, are distinct, diverging posteriorly rather more than in the other species of the genus. The petals are nearly of the same size, but the odd petal is somewhat longer than the others. The petals are rounded at the extremity and closed. The poriferous zones are board, equalling in width the interporiferous space.

The lunules are more or less closed, or simply form open slits, extending over one third the distance of the edge from the apex towards the edge from the apex towards the centre, in prolongation of the median longitudinal axis of the posterior pair of petals. The tuberculation of the upper surface is small, compact, of uniform size, carrying minute, short, fine spines, slightly clavate. The median interambulacral and ambulacral spaces are covered with longer and more distantly spaced tubercles, decreasing in size near the edge, carrying longer and stouter spines. The interambulacral spines are more brilliantly coloured than the ambulacral ones. The ambulacral furrows are not deeply grooved; the posterior pairs branch more frequently near the edge than the others. The mouth is nearly central, slightly anterior. The anus is of irregular outline, more or less circular, placed in a line with the inner extremity of the cuts (slits). The colour of the dried specimens is usually violeest or reddish brown.

Half the internal cavity is occupied by a close network of pillars occupying the whole space from the edge. Between the commencement of the pillars and the slender auricles, the whole actinal floor is covered by a succession of elongated cells, of the

most irregular shapes, formed by the projection of thin lamellae or ridges from the floor which form eventually the pillars extending to the upper floor. The network across the ambulacral spaces is reduced to short, low ridges, running at right angles to the ambulacral tubes.

Koehler (*loc. cit.*, p. 123) reports that most of the specimens of this species in the Indian Museum collection are of small dimensions, their length not exceeding 30 to 35 mm., and some of them are reported to be very small, like those from Palk Strait, the length of which varies between 12 and 15 mm. The lengths of two specimens from Orissa were reported to be 60 and 88 mm., and two others from Santapalli were reported to be much larger. In all the specimens reported by Koehler, the two posterior slits remain open at their distal extremity and this appears to be the condition in the typical form of *Echinodiscus auritus*.

The large primary spines of the ventral surface measure 1.5 to 2.0 millimetres in the large specimens; they are almost cylindrical but slightly widened in their third on in their fourth terminal, then they become narrowed progressively up to the extremity which forms a small, obtuse point. These spines are rather frequently very slightly incurved in their terminal part. They bear throughout their length small, triangular teeth, more or less marked but which are always less developed or disappear in the third terminal Meijere (*loc. cit.*), has indicated the characters of the miliary spines, the integumentary sheath of which is developed up to the extremity of the spine to form a large, rounded expansion. The calcareous stalk is very thin and elongated, measuring from 0.3 to 0.5 mm. in length; the small teeth which it carries throughout its length is developed abruptly towards the extremity to form a small bead.

The miliary spines on the dorsal surface present the same characters as those of the ventral surface. The primary spines which are always of a uniform size are not very much larger than the miliary spines, but they are very much thicker; they maintain the same thickness for two-thirds of their length, then they become widened gradually up to their extremity in such a manner so as to take the form of a club and at the same time they are slightly incurved; the denticulations also become much stronger on this enlarged part.

Meijere mentions of three types of pedicellariae in *Echinodiscus auritus*, namely, tridactyle, trifoliate and ophicephalous; on the other hand, H.L. Clark has only observed the didactyle and bifoliate pedicellariae in this species. Mortensen, however, reports that all the types of pedicellariae encountered in *E. auritus* have three values.

Koehler (*loc. cit.*), has observed in the specimens of this species collected by the Investigator Expedition three sorts of pedicellariae. These are, firstly, the large tridactyle pedicellariae with three values, with which are associated other pedicellariae equally tridactyle, but much smaller and much more delicate. Then there are the bifoliate and the ophicephalous types. The large tridactyle pedicellariae resemble somewhat the rostral pedicellariae which one finds so often in the Spatangids. The values are narrow and elongated and the basal part is narrow and triangular, broader than long, with the margins smooth. The other type of tridactyle pedicellariae are very much smaller than the preceding type; the basal part, however, is more developed and attains almost half the total length of the value. It is broader than long; the limb is short, in the form of a channel or groove and it terminates by a small palette of teeth.

The trifoliate pedicellariae deserve rather the name of bifoliate for they have almost always only two valves. The length of these do not exceed 0.06 mm. The basilar part is very short. The limb remains narrow for about half its length, then it widens rapidly into a club almost as wide as long, furnished for a good part of its length with small teeth extremely fine and close-set. The perforations are rather large.

This is a widely distributed species and has been principally known from the Eastern Coast of Africa (Madagascar, Mozambique, Mombasa, Zanzibar,

Mauritius, etc.), in the Red Sea and from numerous localities in the Indian Ocean. In India, it has been recorded from Karachi and from the Coasts of Madras. It has also been recorded from Ceylon.

Specimens in the collection.—The specimens of *Echinodiscus auritus* in the Museum collection consist of the following lots:

(i) Two wet-preserved specimens in the Reference collection. Locality: Madras.

(ii) Many dry-preserved specimens (including some small, very young, extremely delicate specimens in the Reference collection. Locality: Madras (Some of these specimens are broken into bits).

(iii) Two very large, fine, entire, adult specimens, dry-preserved, exhibited in the Gallery. Locality: Pamban.

These specimens are described below, in greater detail, together with measurements, etc.

(i) Two wet-preserved specimens in the Reference collection. Locality: Royapuram Bay, Madras, Chingleput District. Of the two specimens, the larger one is broken on the left side so that the edge of the disc on this side is incomplete. The specimens are beautifully pale pinkish brown on the upper side and pale dirty greyish white on the under side. The test is covered by a close fur of short, very fine, whitish spines which, along the edge, are longer, and form a continuous fringe of close-set, whitish, hair-like spines all round the border of the test. The petaloid area is small compared to the area of the test and the petals do not meet each other at the centre. The broad, hexagonal plates of which the test is composed are distinct. The branching furrows diverging from the centre on the oral side are distinct and are somewhat yellowish brown or orange-brownish. The oral side is slightly concavely depressed. The posterior margin of the test is straight and abruptly truncated while the sides and the anterior border are more or less evenly rounded. The posterior slits are narrow, rather short and open at the posterior margin.

Measurement:

(a) Smaller, entire specimen:

Length of the test: 42 mm.

Width of the test (at the centre): 43 mm.

Length of the posterior slit: 10 mm.

The test is extremely thin and flattened, being hardly more than 2 mm. in thickness.

(b) Larger specimen, broken along the left border:

Length of the test: 50 mm.

Length of the posterior slit: 12 mm.

Thickness of the test: 3 mm.

The width of the test could not be determined as the edge is broken on the left side.

(ii) Nine dry-preserved specimens and some broken bits of a large specimen in the Reference collection. Locality: Madras. The specimens in this lot range from a tiny young one measuring hardly 20 mm. in diameter to very large ones measuring over 100 mm. in length. Some of these specimens are pale pinkish or purplish brown or purplish grey on the upper side and dirty greyish white or yellowish white or pinkish brown on the oral surface, while others are dark brownish on the upper side and paler brown on the oral side. The large, hexagonal plates of which the test is composed are distinctly seen in some of the specimens and become rapidly and progressively smaller

Towards the centre of the test especially in the areas in between the petaloid ambulacra. In many of these dry specimens the close fur of yellowish white or yellowish brown fine, hair-like spines is still persistent. On the oral side the ambulacral furrows are distinct. They bifurcate at a short distance from the mouth aperture and thereafter are branched in a tree-like fashion. The centre of the test slightly bulged and elevated in most specimens, while the ventral (oral) surface is perfectly flattened.

Measurements :

(a) Largest specimen :

Length of the test : 108 mm.

Maximum width of the test : 115 mm.

Length of the posterior slit : 28 mm.

The shape of the test in this specimen is somewhat broadly triangularly ovate, rounded in front and truncated behind, the maximum width being somewhat behind the middle. The periproct is placed on the oral side in the area between the posterior clefts, a little distance from the posterior truncated margin.

(b) A medium-sized specimen :

Length of the test : 72 mm.

Maximum width of the test : 78 mm.

Thickness of the test : 9 mm.

Length of the posterior slit : 17 mm.

The test is dark brownish in this specimen.

(c) A smaller specimen :

Length of the test : 53 mm.

Maximum width of the test : 59 mm.

Thickness of the test : 4 mm.

Length of the posterior slit : 13 mm.

The test in this specimen is pale pinkish white; the hexagonal plates of the test are distinct on the upper side. The lower side is yellowish white with brownish radial patches towards the border, and the fur of spines is very thick and close-set on the oral side.

(d) A small, young specimen :

Length of the test : 30 mm.

Maximum width of the test : 33 mm.

Thickness of the test : 2 mm.

Length of the posterior slit : 6 mm.

This specimen is pale purplish pink on the upper side and dirty whitish on the lower (oral) side. The hexagonal plates and the fur of spines are distinct, but the petaloid ambulacra are indistinct.

(e) Smallest specimen : (Young specimen) :

Length of the test : 14 mm.

Maximum width of the test : 14 mm.

Thickness of the test : 1 mm.

The posterior slits are hardly formed yet in this specimen, and are in the form of shallow indentations.

In some of the specimens, the outline of the test is even and regular, while in others, the outline is rather wavy and undulating.

(iii) Two large, dry-preserved entire specimens, exhibited in the Gallery.
Locality: Pamban.

The specimens are pale creamy brownish. These specimens are denuded of their fur of spines and their surface consequently presents a finely pitted appearance.

Measurements:

(a) Larger specimen:

Length of the test: 109 mm.

Maximum width of the test: 113 mm.

Thickness of the test: 10 mm.

Length of the posterior slit: 30 mm.

(b) Smaller specimen:

Length of the test: 100 mm.

Maximum width of the test: 102 mm.

Thickness of the test: 9 mm.

Length of the posterior slit: 27 mm.

Echinodiscus bisperforatus (Leske).

FIGURES 49 and 50.

Echinodiscus bisperforatus, Leske, (N.G.), *Addimenta ad Kleinii naturalem dispositionem Echinodermatum*, 1778, p. 196, pl. xxi, figs. A and B.

Lophophora truncata, Agassiz, L., *Monographies d'Echinodermes*, II. *Monographie des Scutelles*, Neuchatel, 1841, p. 66, pl. xi, figs. 11—16.

Echinodiscus biforis, Agassiz, A., "Revision of the Echini" *Cat. Mus. Comp. Zoology*, Harvard, part 3, 1873, pl. xiii b, figs. 5 and 6, part 5, p. 532.

Echinodiscus bisperforatus, Döderlein, *Bericht über die von Semon bei Amboina und Thursday Island gesammelten Echinoidea*, *Jenaische Denkschriften*, 1902, p. 723, pl. lxxv, fig. 6.

Echinodiscus bisperforatus, Clark, H.L., "The Echinoderms of the Western Australian Museum", *Records of the Western Australian Museum*, I, 1914, p. 71.

Echinodiscus bisperforatus, Koehler, R., *An Account of the Echinoidea*, *Indian Museum, Calcutta*, II, *Clypeastrides et Cassidulides*, 1922, p. 128, pl. xv, fig. 9.

Echinodiscus bisperforatus, Clark, H.L., *Catalogue of the Recent Sea Urchins in the Collection of the British Museum (Natural History)*, London, 1925, p. 170.

Echinodiscus bisperforatus, Gravely, "Shells and other Animal Remains of the Madras Beach", *Bulletin, Madras Govt. Museum, (Natural History)*, I, No. 1, 1941, p. 90.

This species is distinguished from the preceding one (*Echinodiscus auritus*) by the shell being somewhat broader than long, with the anus very near the hind margin and by the posterior slits being not confluent with the hind margin.

The test, in *Echinodiscus bisperforatus*, is wider than long, with a narrow linear lunule (slit) in each posterior ambulacrum. The lunules are usually as long as, or longer than, the longest petal. Petals II and IV are longer than petals I and V.

This species presents considerable diversity in the form and in the proportions of the test, the petals and the lunules. Sometimes the lunules are unequal in size in the same specimen.

The outline of the test is irregular, narrower anteriorly, rounded and slightly indented opposite the anterior lateral ambulacra. The greatest width is about half way between the apex and the edge of the test; the posterior extremity is truncated, slightly indented in the direction of the apical opening. The test is much thicker than in *E. auritus* and other species of the genus. The vertex is anterior. The apical system is nearly central. The posterior pair of petals are quite short; the anterior pair are somewhat longer, but still considerably shorter than the odd petal. The outline of the test of young specimens is triangular, with rounded edges.

The lunules are very long, narrow, sometimes narrower in the middle part, forming an obtuse angle with the prolongation of the median axis of the posterior petals. Seen from the actinal side the ambulacral furrows are deep, sharply cut, branching only once or twice quite near the edge; they are very prominent, as they are edged on both sides by minute tubercles, closely packed, giving them the appearance of bare bands, greatly contrasting with the coarse, distant tuberculation of the remaining part of the actinal surface.

In the interambulacra, the largest tubercles are placed along the bare bands of the furrows, becoming smaller towards the median line and the edge of the test, while in the three anterior ambulacral spaces, the largest tubercles are in the median space near the edge of the test, diminishing gradually in size towards the actinostome (peristome). The mouth is small, almost central lobed. The anus is small circular and placed near the edge.

The interior of the test is filled with a calcareous network which is very compact, extending to the extremity of the petals, and leaving only a small open space; this is, however, completely smooth, showing no trace, except a few ambulacral pits, of the delicate tracery covering the floor in the case of the other species. The auricles are extremely small and low; the teeth are remarkably flat, even for this genus. The colour of the dried specimens is dull olive brown.

Koehler (*loc. cit.*), states that in the largest specimen of this species he had examined (in the Indian Museum collection) the length of the test is 45 mm. and the width of the test is 52 mm; the smallest specimen recorded by him measures 27 mm. in length and 30 mm. in width.

The largest primary spines of the ventral surface are cylindrical and in general, very thin, with the extremity rounded. They are armed with denticulations, very fine and very close set over a greater part of their length. These measure 1.5 mm. The other spines, more numerous, are shorter and their length does not exceed 0.6 to 0.8 mm.; they are flattened rapidly and are widened in the second half up to the vicinity of their extremity. They acquire at the same time teeth which become stronger on the widened part. This widened part is ordinarily a little curved and the teeth are more developed on the convex side on the concave side.

Compared to those of *E. auritus*, these spines are more feeble (weaker) and shorter, but the widened terminal part is more marked. The primary spines of the dorsal surface have the same characters as in *E. auritus*; their length does not exceed 0.5 to 0.6 mm. The miliary spines have almost the same dimensions and they present the same characters as in *E. auritus*.

Koshler (*loc. cit.*), has observed two types of pedicellariae in this species; the tridactyle and the bifoliate. The tridactyle pedicellariae are of two sorts; the first type have the head rather developed and they are analogous to the large tridactyles of *E. auritus*. The valves have a length of about 0.3 mm; they are truncated at the extremity and bear throughout their length conical teeth and rather low spaces. The pedicellariae of the second type appear rather well represented and are very much smaller than the preceding type. The valves measure 0.12 to 0.15 mm. in length. The basal part is widened and rather high. The limb, at first very broad, narrows down next and then widens again to form a club which occupies the half of its length. This club, which is not very large, has the shape of a very elongated oval, of which the margins carry in the terminal part some teeth, at first very small, conical and low, but which elongate very much towards the extremity. The perforations, rather large, are rounded or elongated. These are those pedicellariae which have been mentioned by H.L. Clark who compared them to those of *E. tenuissimus*, but Koshler observes that in these last, the limb forms an elongated club the margins of which remain simply parallel and which is not widened like that in *E. bisperforatus*.

The bifoliate pedicellariae are extremely small and their valves do not measure more than 0.005 mm. The basal part is extremely short; the limb forms at first a narrow, shorter part, as in *E. auritus*, and it widens into a club, a little wider than long, armed on the borders with a few rather broad, elongated and conical teeth; the perforations are rather large, few in number, elongated in the median part of the limb, and rounded on the sides; this club is comparatively broader than in *E. auritus*.

Koehler (*loc. cit.*), records five specimens of this species from the Coast of Madras at a depth of seven fathoms in the Indian Museum collection.

This species is recorded from the Gulf of Suez, Red Sea, Abyssinia, Natal, Port Natal, Cape Colony, Mossal Bay, Madras, New Caledonia and West Australia. It has also been recorded from the Gulf of Manaar, this record being based on the specimens of this species represented in the Museum collection.

Specimens in the collection.—The specimens of *Echinodiscus bisperforatus* in the Museum collection include both wet-preserved and dry-preserved ones and consist of the following lots:—

(i) Four wet-preserved specimens (in alcohol) in the Reference Collection. Locality: Kutikal Channel, Gulf of Manaar. The specimens are moderate-sized, ranging from 31 mm. to 46 mm. in maximum diameter. Two of the specimens are almost pure white, while the largest specimen and the smallest one are brownish. The petaloid ambulacra are broadly ovate and the posterior slits are rather short and broad. The close fur of short, slender white spines is well seen, and is especially well developed on the oral side. In the smallest specimen, the posterior border is broken at the ends of the two slits, so that the slits are open at the posterior end.

Measurements:

(a) Largest specimen:

Length of the test: 43 mm.

Maximum diameter of the test: 46 mm.

Thickness of the test at the middle: 6 mm.

Length of the posterior slit: 6 mm.

(b) Smallest specimen:

Length of the test: 27 mm.

Maximum diameter of the test: 31 mm.

Thickness of the test at the middle: 4 mm.

Length of the posterior slit: 5 mm.

The ventral, bifurcating furrows and the pale, radially widening areas radiating from the centre in between the furrows are distinct.

The other two specimens are intermediate in size between these two specimens.

(ii) Seventeen dry-preserved specimens, including two very young and immature specimens in the Reference Collection. Locality: Ennur and Madras Beach.

The specimens range in size from 45 mm. to 72 mm. in maximum diameter, but the two young ones are very small and immature, about 20 mm. in diameter and are in a very fragile condition, being broken and incomplete. A few of the adult specimens in this lot are also broken and hence not entire.

Most of the specimens in this lot are almost whitish or pale dirty brownish white. The posterior border is broad and truncated while the anterior border is broadly rounded. The posterior slits are narrow and elongated. The furrows on the ventral side are distinct and bifurcate almost immediately on leaving the mouth at the centre, and the posterior pairs of these furrows enclose the posterior slits. The margin of the test is sometimes even, sometimes undulating slightly.

Measurements:

(a) Largest specimen:

Length of the test: 67 mm.
Maximum diameter of the test: 74 mm.
Thickness of the test: 9 mm.
Length of the posterior slit: 23 mm.

(b) Smallest specimen (excluding the two young specimens):

Maximum of diameter of the test: 45 mm.
Length of the test: 41 mm.
Thickness of the test: 5 mm.
Length of the posterior slit: 11 mm.

The other specimens in this lot are intermediate in size between these two. In one of the specimens, the posterior portion (including the slit) is badly broken, while in another broken specimen only one half is present. In one of the specimens, two adult specimens of the barnacle, *Balanus amphitrite*, with pink-coloured shells are found attached to the upper side, while in another there are numerous small, white young specimens of barnacles (probably of the same species) found attached on the upper surface, but portions of the upper surface of the test are found broken away in this specimen.

The two very young and smallest of the specimens are too badly broken for their measurements to be determined accurately. The larger one of these is about 20 mm. in diameter.

In all these specimens, the upper side is slightly convexly arched, while the oral surface is almost perfectly flattened and even slightly concavely depressed.

(iii) Two dry-preserved specimens, exhibited in the Gallery, Locality: Ennur.

The specimens are slightly pale dirty brownish white on the upper side and chalky white on the lower (oral) surface. The outline of the test slightly undulating in both the specimens.

Both are almost exactly of the same size.

Measurements (of one of the two specimens):

Length of the test: 53 mm.
Maximum diameter of the test: 59 mm.
Thickness of the test: 7 mm.
Length of the posterior slit: 18 mm.

Echinodiscus bisperforatus. var. truncatus (Agassiz).**FIGURE 51.**

Scaphophora truncata, Agassiz, Mon. Ech., Mon. Scutellidae, 1841, p. 66, pl. xi, figs. 11—16.

Echinodiscus bisperforatus var. *truncatus*, Clark, H.L., Memoirs of the Museum of Comparative Zoology, 46, 1914, p. 72.

Echinodiscus bisperforatus var. *truncata*, Clark, H.L., Catalogue of the Recent Sea Urchins in the Collection of the British Museum (Natural History), London, 1925, p. 170.

Echinodiscus bisperforatus var. *truncatus*, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum (Natural History), V. No. 1, 1941, pp. 89 and 106.

This variety is distinguished from the typical form, *E. bisperforatus* s. str. by the lunules being very short, as short as the shortest petals; but, as a rule, they are a trifle longer than the shortest petals. They are also broader than in the typical form.

This subspecies is represented in the Museum collection by a single specimen collected from Covelong on the Madras Coast in 1939.

Clark, (*loc. cit.*), records specimens of this variety from Penang and New Caledonia in the British Museum collection.

Specimens in the collection: One dry-preserved specimen in the Reference collection.
Locality: Covelong, Madras, 1939.

In this variety the posterior slits are short, relatively broad, rather shallow and open towards the posterior edge and the posterior margin in between these slits is somewhat angularly truncated. Presumably, the posterior edge is broken and incomplete in the present specimen. The petaloid areas and the poriferous zones are much the same as in the typical form of the species.

The furrows on the ventral (oral) side are less deeply incised and less distinct in this specimen than in those of the typical form examined. But the rows of hexagonal plates making up the test are more distinctly seen in this specimen. The specimen is dirty whitish throughout.

Measurements:

Length of the test: 42 mm.

Maximum diameter of the test: 46 mm.

Thickness of the test in the middle: 6 mm.

Length of the posterior slit: 7 mm.

The ventral (oral) side is absolutely flat in this specimen and does not show any sign of concavity.

ORDER SPATANGOIDA.

The Spatangoids include the urchins popularly known as the heart urchins. They are irregular Echinoids of mostly oval shape, usually elongated, with the structures of the test arranged symmetrically in relation to the axis of elongation. The anterior

ambulacrum is often indented at the ambitus, giving the test a cordiform outline. The ambulacra, except the anterior one, are generally petaloid aborally, and may be flush with the surface or more or less deeply insunk. Phyllodes are generally present, but bourrelets are usually wanting. On the oral side, the posterior interambulacrum is often slightly elevated and forms a plastron. The peristome is displaced anteriorly, so that the three anterior ambulacra are shorter than the two posterior ones. The apical system consists of separate plates, with two to four gonopores. The spines are mostly short and slender and the larger ones are usually curved and held parallel to the surface of the test, appearing as if combed back, and often arranged in tracts. Peculiar to the Spatangoids are the fascioles which are narrow bands composed of closely crowded, minute tubercles that support special, tiny, ciliated spines. A masticatory apparatus is completely wanting.

The Spatangoids typically burrow in sand or mud at the sea bottom and many of their peculiarities are therefore adaptations to this form of life.

The existing Spatangoids are divided by Mortensen into (i) the meridiosternous forms in which the labrum abuts posteriorly with a single plate of the plastron, and (ii) the amphisternous forms in which it abuts on two plates.

Three families of this Order are represented in the Museum collection. All these three families belong to the group of "Amphisternous forms" in which the labrum abuts posteriorly on two plates.

GROUP II. AMPHISTERNOUS FORMS.

The Amphisternous Spatangoids, in which the posterior end of the labrum abuts on two equal plates of the plastron, comprise the most typical members of the Order and include a wealth of forms. Fascioles are well developed, the paired ambulacra and more or less clearly petaloid, phyllodes are generally present, and the podia occur in a variety of non-locomotory forms.

FAMILY SPANTANGIDAE.

The members of this family are distinguished by the presence of only the subanal fasciole. The apical system is ethmolytic, that is, the madreporite has moved into a symmetrical position with reference to the four genitals. In most of the typical members of this family, the test is large, aborally arched and cordiform, with the petaloids flush with the surface and with a spiny plastron. In the genus *Pseudomaretia* (which is the only genus of this family represented in the Museum collection), the plastron and the adjoining areas are almost devoid of spines.

The peristome, in the family Spatangidae, is transversely elongated; some or all of the ambulacra are more or less petaloid, or more or less sunken, or both. A subanal fasciole is present.

Formerly, this family was large and included several forms which now have been separated into distinct families.

This family includes forms with a more or less flat test; the petals are lanceolate, with broad, interporiferous spaces flush with the test; the abactinal parts of the poriferous zones are usually rudimentary.

The genera of this family have no peripetalous fasciole. In some genera, there is an internal fasciole, forming a plastron which is placed above the margin, in the anterior part of the test and partially obliterates the abactinal part of the anterior poriferous zone of the anterior lateral ambulacra.

A single species of this family, *Pseudomaretia alta*, belonging to the genus *Pseudomaretia*, is represented in the Museum collection.

Genus *Pseudomaretia* Koehler.

The test is rather elevated, and the dorsal surface strongly convex, being raised progressively from the anterior to the posterior extremity. This surface is uniformly covered with secondary tubercles and there exists only a very small number of primary tubercles in the two posterior inter-radii in the neighbourhood of the ambitus. The genital orifices are only three in number. The posterior ambulacral avenues of the ventral face are relatively narrow. The posterior extremity of the test is truncated and slopes obliquely to the front. Its superior part on top of the sub-anal plastron is occupied entirely by the opening of a large and deep invagination which projects into the interior of the test. The periproct which is found at the bottom of the invagination is transformed into a sort of transverse ampoule widened at each extremity into a large, rounded vesicle attached to the internal surface of the test.

The pedicellariae are very abundant. The tridactyle pedicellariae are more well developed, with fusiform peduncle, identical with those which Döderlein has observed in *Lovenia elongata* and *L. subovato*, and which is found on the ventral surface, on the posterior ambulacral avenues. The digitations of the anal pedicels form each a very strong and thick stem, identical to those of the anal pedicels of *Echinocardium cordatum* and are quite different from the narrow and slender ones which are found in the peristomial pedicels. These different characters do not exist in the genus *Maretia* from which, therefore, Koehler separated the present genus as a distinct one.

The sternum is small and wide, with the primary tubercles confined to the posterior end; the genital pores are three in number. The periproct is deeply sunken and overhung by the posterior end of the test.

This genus is represented in the Museum collection by a single species, *Pseudomaretia alta*, which is the type of the genus.

Pseudomaretia alta (Agassiz).

FIGURES 52 AND 53.

- Maretia alta*, Agassiz, A., Proc. Acad. Nat. Sciences Philadelphia, 1863, p. 360.
- Maretia alta*, Agassiz, L., "Revision of the Echini", Catalogue, Mus. Comp. Zoology, Harvard, 1872—1874, pt. 5, p. 569.
- Maretia alta*, De Loriol, Echinodermes de l'île Maurice, Mem. Soc. de Physique et d'hist. nat. Geneve, XXVIII, 1883, No. 8, p. 49.
- Maretia alta*, Döderlein, Echinodermen von Ceylon, Zool. Jahrb. Abth. f. Syst., III, 1888, p. 838.
- Maretia alta*, Walter, Ceylon's Echinodermen, Jen. Ztschr. f. Naturw., XVIII, p. 377.
- Maretia alta*, Anderson, "On Some Indian Echinoidea", Journ. Asiatic Soc. Bengal, LXIII, 1894, p. 188.
- Maretia alta*, Bell, Echinoderm Fauna of Ceylon, Scientif. Transact. Roy. Dubl. Soc., (2), III, 1887, p. 652.
- Maretia alta*, Bell, Fauna and Flora, Maldive and Laccadive Archipelago, p. 233.
- Maretia alta*, Meijere, Siboga-Expeditie, Echinoidea, XLIII, Livr. 14, 1904, p. 192.

Pseudomaretia alta, Koehler, "An Account of the Echinoidea", Indian Museum, Calcutta, II, Spatangides, 1914, d. 107, pl. xi, figs. 9, 14—17, and 20.

Pseudomaretia alta, Clark, H.L., Catalogue of the Recent Sea Urchins in the Collection of the British Museum (Natural History) London, 1925, p. 228.

Pseudomaretia alta, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Museum (Natural History), V, No. 1, 1941, p. 91.

The test is high posteriorly; the interambulacra 1 and 4 bear 3 or 4 large primary tubercles in a group near the ambitus.

The outline of the test from above is elliptical, rounded anteriorly, with a slight indentation at the ambitus, formed by the shallow anterior groove. The posterior extremity is truncated, nearly vertically, across the extremity of the petals. Seen in profile, the test is uniformly rounded from the anterior edge to the apical system, and rises gradually to the vertex, which is slightly anterior to the truncated posterior extremity. The test slopes regularly from the central line to the lateral edges of the test. The apical system is anterior. The petals are narrow, lanceolate, extending nearly to the edge of the test. The anterior poriferous zones of the anterior lateral ambulacra are obliterated, with the exception of three or four outer pairs of pores. The anterior odd ambulacrum is narrow, reduced to a few vertically distant pores, flattened near the apical system by a few larger primary tubercles; the rest of the abactinal surface, with the exception of a few large primary tubercles near the edge of the test in the posterior lateral interambulacra is covered by minute, closely crowded secondary tubercles, carrying short slender, curved spines. On the actinal surface, the tubercles increase in size towards the bare ambulacral avenues, and are arranged diagonally, carrying proportionately longer and stouter spines. The actinal plastron extends half way to the actinostome (peristome) from the subanal plastron, forming a sharp break at its posterior edge. The subanal plastron is heart-shaped, placed entirely within the truncated posterior extremity, surrounded by a broad fasciole, which extends to the lower edge of the large, transversely elliptical anal system, placed at the upper edge of the truncated posterior plane.

The proportions of the anal system of the subanal and actinal plastron, with the beak at its posterior edge, and the high test readily distinguish this species from the closely allied species, *Pseudomaretia planulata*.

In the living condition, the colour of the test of *Pseudomaretia alta* is said to be a light buff above, marked with radiating rows of flesh-coloured patches. But Clark, (*loc. cit.*), records specimens which are deep reddish purple in colour. No large specimens of this species have been found. They usually range in size from about 23 x 19 mm. to 40 x 33 mm.

This species has been recorded from Tuticorin and Carcados, Carajos and from Japan, and also from Pedro Shoal, Andaman Islands and from Pooria.

This species appears to be rare around the Madras Coast and in the Madras Museum collection, only a single specimen of this species, from Royapuram Bay, Chingleput district, is represented.

Specimens in the collection.—One wet-preserved specimen (in alcohol) in the Reference Collection. *Locality*—Royapuram Bay. Chingleput district.

The specimen is small, elongately ovate and heart-shaped, pale greyish brown above and dirty whitish below. The spines are short, slender, whitish and lie flat over the surface of the test, appearing as if combed back. Towards the ambitus and on the ventral

(oral) surface the spines are longer and more closely crowded. The petaloid ambulacra on the abactinal side are distinct, narrow, lanceolate, the two posterior ones being much longer than the others. The posterior extremity is narrow and truncated.

The petaloid ambulacra are of a darker brown colour than the surrounding areas. On the actinal side, the tubercles increase in size, carrying proportionately longer spines. The subanal plastron is heart-shaped and is surrounded by a broad fasciole.

Measurements:

Length of the test: 25 mm.

Maximum width of the test: 20 mm.

Height of the test: 10 mm.

Length of the posterior petaloid ambulacrum: 10 mm.

Length of the lateral petaloid ambulacrum: 6 mm.

Family LOVENIDAE.

The family Lovenidae differs from all other Spatangoids by the presence of an internal fasciole that encloses the apical system and much of the anterior ambulacrum. The test is of moderate to large size, rather low, and of cordiform outline. The four petaloids are well developed, flush with the test. On the aboral side, between the petals, there are often large tubercles, with deeply sunken areoles; these tubercles in life carry long, curved spines directed backward. The apical system is ethmolytic as in the Spatangidae, with nearly always four gonopores.

Formerly, members of this family were included in the family Spatangidae, but later they were separated into a distinct family.

A single genus of this family, namely, *Lovenia*, is represented in the Museum collection by the familiar species *Lovenia elongata*, common in the Indo-Pacific Region.

Genus *Lovenia* Agassiz and Desor.

The ambulacral plates are somewhat triangular, the adjoining zones forming two crescents on each side of the apex, with the concave sides towards each other.

The test is thin, elongate, arched, flattened and truncated posteriorly. Large tubercles are present on the upper part of the test, except in the posterior ambulacrum. Remarkably large ampullae support the large tubercles and form a close pavement on the inner surface over the whole floor of the actinal portions of the test; they correspond to the large tubercles of the upper part of the test; these commonly carry long, curved spines; the anterior groove is slight and the pores are very small.

An internal fasciole is present, but there are no peripetalous fascioles. Large, deeply sunken primary tubercles are present in the interambulacra on both the upper and lower surfaces. The sternum has the tubercles confined to its posterior part. Petals I and V are well formed.

A single species, *Lovenia elongata*, which is widely distributed in the Indo-Pacific Region and is common on the Madras Coast, is represented in the Museum collection by several specimens (mostly dry-preserved tests), but live specimens have also been collected on Krusadai Island in the Gulf of Manaar.

Lovenia elongata (Gray).

FIGURES 54 AND 55.

Spatangus elongatus, Gray, Eyre, J., Exped. Australia, 1, 1845, p. 436.

Lovenia elongata, Agassiz, Al., "Revision of the Echini", Cat. Mus. Comp. Zoology, Harvard, 1872-1874, pt. 5, p. 575; pl. xixc, figs. 1-4, pl. xxv, fig. 31; pl. xxvi, figs. 35 and 36; pl. xxxvii, figs. 17 and 18; pl. xxxviii, figs. 27 and 28.

- Lovenia elongata*, Agassiz, Al., Challenger Reports, Echinoidea, p. 175.
- Lovenia elongata*, Bolau, Die Spatangiden des Hamburger Museums, Abhand. naturw. Vereins Hamburg, 1873, p. 7.
- Lovenia elongata*, Bell, Report, Zool. Coll., "Alert", London, 1884, p. 123.
- Lovenia elongata*, Bell, Echinoderms of Port Philip, Ann. and Mag. Nat. Hist., (6), II, p. 402.
- Lovenia elongata*, Bell, "Report on a Collection of Echini from Australia", Proc. Linn. Soc. N.S. Wales, IX, p. 503.
- Lovenia elongata*, Ramsay, Catalogue of Echinoderms in the Australian Museum, Echini, 1885, p. 53.
- Lovenia elongata*, Döderlein, Echinodermen Von Ceylon, Zool. Jahrb. Abth. f. Syst., III, 1888, p. 838.
- Lovenia elongata*, Döderlein, Seeigel von Japan und den Liu-Kiu Inseln. Archiv. f. Naturg. Jhr. 51, I, p. 107.
- Lovenia elongata*, Bell, "Report on a Collection of Echinoderms made at Turicorin. Madras", Proc. Zool. Soc. London, 1888, p. 384.
- Lovenia elongata*, Koehler, R., Echinodermes recueillies par M. Korotnev aux îles de la Sonde, Mem. Soc. Zool. de France, 1895, p. 416.
- Lovenia elongata*, Ludwig, Echinodermen des Sansibargenbietes (ges. von VOELTZKOW), Abhandl., Senckenb. naturf. Gesellsch., XXI, p. 556.
- Lovenia elongata*, Bedford, "On Echinoderms from Singapore and Malacca", Proc. Zool. Soc. London, 1900, p. 286.
- Lovenia elongata*, Anderson, Rep. Marine Survey, India, 1898—1899, p. 5.
- Lovenia elongata*, Bell, Fauna and Geography of the Maldiva and Laccadive Archipelagoes, p. 232.
- Lovenia elongata*, Meijere, Echinoidea, Siboga-Expeditie, 1904, XLIII (livr. XLIV), p. 193.
- Lovenia elongata*, Fourteau, R., Contribution à l'étude des Echinides vivantes dans le Canal Suez, Bull. Institut Egypte (4), IV, 1904, p. 429.
- Lovenia elongata*, Koehler, R., "An Account of the Echinoidea", Indian Museum, Calcutta, II, Spatangides, 1914, p. 111; pl. xi, figs. 5 and 6; pl. xii, fig. 10; pl. xiii, fig. 8, pl. xix, figs. 25 to 32.
- Lovenia elongata*, Clark, H.L., "Catalogue of the Recent Sea Urchins in the Collection of the British Museum (Natural History)", London, 1925, p. 230.
- Lovenia elongata*, Gravely, Littoral Fauna of Krusadai Island, Bull. Madras Government Mus., Natural History, I, 1927, p. 171.
- Lovenia elongata*, Gravely, "Shells and other Animal Remains of the Madras Beach", Bull. Madras Government Mus., V. No. 1, 1941, p. 91.

The test is depressed, rather flat, and pointedly heart-shaped from above; the edge of the test is angular; the anterior groove is deep at the ambitus; the posterior interambulacral space is extended, truncated and bevelled inwardly. The greater width is between the apical system and the anterior edge. The four genital openings are located close together. The madreporic body is small. The internal fasciole is of uniform breadth, surrounding an elongate, posteriorly pointed plastron, crossing the ambulacra at right angles, slightly concave, towards the apical system; the odd ambulacral zones run along the edge of the flat abactinal plastron, the anterior half of which is covered on both sides of the odd ambulacrum by rows of secondary tubercles, with sunken, scrobicular circles on the posterior edge only, five to six in each row, diverging from the anterior ambulacrum, which is flat, with a narrow, interporiferous space, covered by minute granulation (miliaries) in the centre, while between the pores on the edge there are minute secondary tubercles, with flat, scrobicular circles, similar to those covering the remainder of the internal plastron, but smaller. The anterior ambulacral plates are triangular, while the anterior poriferous zones are obliterated. The posterior zones form, with the anterior zones of the posterior lateral ambulacra, a nearly confluent arc, separated by a short space, formed by the narrow, abactinal part of the interambulacral space.

The posterior petals are more elongate, the posterior zones meeting at the posterior edge of the internal plastron, which extends a short distance beyond the apical system. The poriferous zones of the lateral ambulacra are slightly sunken; the pores are vertically widely separated, and the zones are continued to the edge of the test, flush with the test, as pairs of small pores placed close together. The anterior groove commences at the anterior edge of the abactinal plastron, the flat plastron extending below the fasciole along the sides of the groove to form a flat keel. The abactinal part of the test, outside the fasciole, is covered by minute, closely packed, raised secondary tubercles of a uniform size, with a few distant miliaries. In the anterior interambulacra, and the anterior half of the lateral posterior interambulacra, there are large, primary tubercles, perforate, not crenulate, with deeply sunken, scrobicular circles of various sizes, carrying powerful, long, curved spines, often equalling two-thirds of the test in length.

On the actinal side, the tubercles of the interambulacral spaces increase in size rapidly towards the bare ambulacra; the scrobicular circles are deeply sunken; and the tip of the tubercle is bridged by a narrow space, curving outward, connecting it with the anterior part of the test.

The actinostome (peristome) is crescent-shaped with rounded ends, twice as broad as long. The phyllodes are short; the pores are distant (widely separated) but prominent. The actinal surface (i.e., the oral surface) is nearly flat, the posterior lip of the actinostome forming a slight keel. The bare spaces of the ambulacra are connected, so that the greater part of the actinal surface is free from tubercles. The actinal plastron is semi-circular, limited to the posterior extremity of the actinal surface. The posterior extremity slopes anteriorly from the upper edge. The anal system is situated at the bottom, on the upper side, of the deep inverted funnel, which divides the subanal plastron into two almost disconnected portions. The fasciole is convex posteriorly behind the actinal plastron forming two lateral loops, which spread over the edge, so as to cover the whole of the inverted funnel of the posterior extremity below the anal system. The anal system is longitudinally elliptical, pointed towards the lower edge, the membrane is covered by an outer row of large plates, with smaller concentric rows of plates towards the anal opening. On the lateral shields of the subanal plastron there are from eight to ten large primary tubercles, carrying long, stout, curved spines, forming two tufts on each side of the sunken posterior extremity. The primary tubercles of the actinal side (oral side) carry long, slender spines, less curved than those of the abactinal side. The actinal plastron is covered by minute secondaries, somewhat larger towards the anterior edge, carrying short, stout, curved spines, while the spines of the abactinal surface are short, slender and silk-like. The ambulacra on the actinal side are covered by slender, short spines, mounted on miliary tubercles, scattered irregularly.

The colour of the specimens in alcohol is a brilliant light violet. On the actinal side, the colouring is lighter and of uniform tint. In small specimens, the colouration is uniform and the large spines are not prominently banded. The young are usually long and high, while larger and older specimens become gradually broad, flat and angular.

There is considerable variation in the size and colour of the tests of the specimens in this species. Some are reddish violet, with the long spines yellowish.

The genital pores are four in number. The periproctal region is deeply sunken. The test is wide and low. 6 to 10 large pore pairs are present on each side of the subanal plastron.

Meijere (*loc. cit.*), records some young specimens of this species from Ambon (30 to 40 mm. in length) in the Siboga Expedition Collection. The big spines on the apical side in these specimens are ringed black and white. The others are violet brown in colour. The big spines found on the small specimens are very few in number, for instance, in the specimen from Makassar in the Siboga Expedition Collection (19 mm. in length) there are reported to be only two, one above the other, respectively, in front of and behind the middle ambulacral plates.

This species has a wide distribution ranging from the Coast of East Africa through the Indo-Pacific Region on to Australia. Specimens of this species have been recorded from Aden, Muscat, British East Africa, Tuticorin on the East Coast of Peninsular India, Macclesfield Bank, Phillippine Islands, Japan, Torres Strait, Thursday Island, North Australia, Port Essington and East Coast of Queensland. This is also the only species of Irregular sea urchin that has been collected alive in the Gulf of Manaar area (Gravely, *loc. cit.*, 1927, p. 171).

Specimens in the collection.—Specimens of this species are represented in the Museum Collection only from the Pamban area. One wet-preserved specimen in alcohol from Rameswaram in the Reference collection and four dry-preserved specimens from Pamban exhibited in the Gallery, are contained in the Museum collection. This species has only rarely been taken alive in the Pamban area:

(i) One specimen, wet-preserved, in the Reference Collection. Locality: Rameswaram, 1925.

The specimen is moderate-sized, heart-shaped, dirty greyish white, with long, slender, white spines lying flat against the surfaces and appearing as if combed back. The posterior end is truncated and the anterior margin slightly notched in the middle. The ventral (oral) surface is absolutely flattened, with the spines concentrated towards the margins. The primary spines arise from large primary tubercles which are placed in deep, socket-like pits.

Measurements:

Length of the test: 42 mm.

Maximum width of the test: 33 mm.

Height of the test: 17 mm.

Length of the posterior petaloid ambulacrum (which alone is distinct in the present specimen): 16 mm.

(ii) Two dry-preserved specimens, with most of their spines intact, exhibited in the Gallery. Locality: Pamban.

Both the specimens are dark brown in colour, and are almost of the same size.

Measurements (of one of the specimens):

Length of the test: 48 mm.

Maximum width of the test: 40 mm.

Height of the test: 19 mm.

The petaloid areas are not distinct as they are occluded by the spines.

The spines are long, brownish, slender and needle-like and lie flat on the test, appearing as if combed back.

The other specimen is almost exactly of the same size.

(iii) Two dry-preserved specimens—dry tests denuded of their spines. Locality: Pamban.

These two specimens are brownish, (slightly paler brown than the preceding species), and as they are bare tests, completely denuded of their spines, the petaloid areas and the tubercles and the pits in which the primary tubercles are imbedded and their distribution and disposition are clearly seen. On the aboral side these primary tubercles are fewer and set rather widely apart and are confined to the four wide anterior inter-ambulacral areas, while on the flattened oral side these primary tubercles in sockets are more numerous, and more closely crowded together and are confined to the marginal areas near the ambitus. The central, broad, furrow-like depression on the anterior half of the aboral surface, the broad and fairly deep central indentation on the anterior margin, the numerous small secondary tubercles and the petaloid areas are also distinctly seen in these specimens as they have been denuded of their spines. Of the two specimens, one is slightly larger than the other. The concavely depressed and broadly truncated posterior margin and the transversely elongated periproct near the hind end of the oral surface are also clearly made out in these specimens.

Measurements :

(a) Smaller specimen :

Length of the test : 40 mm.

Maximum width of the test : 36 mm.

Height of the test : 15 mm.

Length of the posterior petaloid ambulacra : 15 mm.

Length of the anterior lateral petaloid ambulacrum : 13 mm.

(b) Slightly larger specimen :

Length of the test : 44 mm.

Maximum width of the test : 37 mm.

Height of the test : 15 mm.

Transverse length of the periproct : 13 mm.

The measurements of the petaloid areas in this specimen could not be determined as the specimen is firmly glued on the display board by its aboral side and hence could not be detached from the board without risk of damage to the specimen.

Family BRISSIDAE.

This is the last of the families included in the Order Spatangoida and is distinguished by the combination of peripetalous and subanal fascioles; and branches from the latter along the sides of the periproct are generally present. The petaloidis are usually not much sunken, and this also applies to the anterior ambulacrum. This family includes several widely distributed genera occurring both in the Indo-Pacific Region and in the Atlantic and Panamic Regions.

A single genus, *Metalia*, is represented in the Museum collection.

Genus *Metalia* Gray.

The test is big, wide and high; and anal fasciole is present on each side of the periproct; no big primary tubercles are present within the peripetalous fasciole.

A more or less broad, elliptical or undulating, re-entering peripetalous fasciole and an anterior ambulacral groove are present. The lateral ambulacral plates are narrow and elongate. The pores are well separated; the apex is anterior. The actinal plastron is narrow and heart-shaped. The subanal area is bordered by a broad fasciole, with anal branches connected with it. The subanal ambulacral pores send out radiating grooves towards the centre of the subanal area. The actionstome (peristome) is anterior and crescent-shaped. The tuberculation of the peripetalous fasciole is coarse, frequently consisting of primary tubercles. The spines are short, slender and curved, those of the actinal (oral) surface being longer, curved and broad at the base of the milled ring.

In this genus, the peripetalous fasciole does not bend inward markedly between the petaloids, and the shield-shaped subanal fasciole gives off anal branches. Large tubercles are absent. The several species of this genus are found mostly in the tropical West Pacific, except *Metalia nobilis* which is from the Panamic Region.

This genus is represented in the Museum Collection by a single species, *Metalia sternalis* (Lamarck) of which a single, dry-preserved specimen from Tuticorin is contained in the collection.

***Metalia sternalis* (Lamarck).**

FIGURE 56.

Spatangus sternalis, Lamarck, *Histoires Naturelle des Anim. sans Vertebres*, III, 1816, p. 31.

Brissus (Metalia) sternalis, Gray, *Cat. Recent Echinoidea*, British Museum, 1855, p. 51.

Metalia sternalis. Agassiz A., "Revision of the Echini", *Cat. Mus. Comp. Zool.* Harvard, 1872-1874, Part 3, pl. a, figs. 4 and 5; pl. xxi c, figs. 5-9; Part 5, p. 600.

Metalia sternalis, Tenison Woods, "The Echini of Australia" *Proc. Linn. Soc. N.S. Wales*, II, 1878, p. 175.

Metalia sternalis, Tenison Woods, "On some new Australian Echini", *Ibid.*, IV, 1880, p. 290.

Metalia sternalis, De Loriol, *Echinodermes de l'île Maurice*, *Mem. Soc. de Phys. et d'hist. nat. de Geneve*, XXVIII, 1883, No. 8, p. 44.

Metalia sternalis, Döderlein, *Seeigel von Japan und den Liu-Kiu-Inseln*, *Archiv. f. Naturg. Zhrg.*, 51, 1885, p. 139.

Metalia sternalis, Bell, *Report on a Collection of Echinodermata from the Andaman Islands*, *Proc. Soc. Zool. London* 1887, p. 140.

Metalia sternalis, Bell, "Report on the Echinoderms from Tuticorin, Madras", *Proc. Zool. Soc. London*, 1888, p. 384.

Metalia sternalis, Sultiter, *Die Echiniden-Sammlung des Museums zu Amsterdam* *Bijdragen tot de Dierkunde*, XVII, 1895, p. 74.

Metalia sternalis, Ludwig, *Echinodermen des Sansibargebietes* (ges von VOELTZKOW) *Abhandl. Senckenb. naturf. Gesellsch.*, XXI, p. 556.

Metalia sternalis, Bedford, "On the Echinoderms from Singapore and Malacca" *Proc. Zool. Soc. London*, 1900, p. 286.

Metalia sternalis, Anderson, "On some Indian Echinoidea", Journ. Asiatic Soc. Bengal, LXIII, 1894, p. 188.

Metalia sternalis, Farquhar, "On the Echinoderm Fauna of New Zealand", Proc. Linn. Soc. New South Wales, XXII, p. 322.

Metalia sternalis, Meijere, Echinoidea, Siboga-Expeditie, XLIII (Livr. 14), 1904, p. 185, pl. xxii, fig. 464; pl. xxiii, figs. 465-468.

Metalia sternalis, Clark, H.L., Catalogue of the Recent Sea Urchins in the Collection of the British Museum (Natural History) London, 1925, p. 216.

This species grows to a large size, and the differences due to age are quite remarkable. In the largest specimens (measuring 150 mm. in length), the outline of the test from above is elliptical, slightly angular, and truncated posteriorly. The anterior edge is deeply indented at the ambitus by the ambulacral groove. When seen in profile, the test rises vertically at the anterior extremity almost to the summit. The apical system is anterior, within the depressed abactinal part of the interambulacra which rises above the general level of the termination of the petals. The posterior part of the test is concave. From the apical system towards the posterior edge, the abactinal surface of the test is flattened.

In specimens slightly younger, the posterior part of the test, seen in profile, is straight; it is even convex near the edge of the posterior part of the interambulacrum.

The genital pores are large, circular and close together. The odd ambulacral groove is shallow, flat at the abactinal pole, becoming deeper towards the edge, but narrowing again below the peripetalous fasciole. The lateral anterior ambulacra are sunken, broad, elongate and somewhat rounded at the extremity. The poriferous zones are broad, the pores being large and connected by a deep groove. The abactinal part of the anterior ambulacra is pointed, the poriferous zones forming a slight angle with the trend of the rest of the petal. The lateral posterior ambulacral petals, for a considerable distance from the apical system, are narrow, elongate, slightly diverging, running parallel to the narrow interambulacral space which separates them. At about one-third of its length, the inner poriferous zone, which remains thus far rudimentary, reduced to a mere line of distant pores, increases rapidly in width, the whole course of the petal is deflected outwardly, and at about half the length of the petal. The two poriferous zones are of equal width, and, remaining so, run almost parallel to the extremity, where the poriferous zones become somewhat narrower at the rounded end of the petal. The outer portion of the petal curves slightly inward. The actinal (oral) surface of the large specimens is convex, flattened in the median interambulacral space and rounded towards the edges, especially in the lateral posterior interambulacral spaces. The flat actinal plastron is narrow, elongate and rounded at the two extremities, with a slight keel, forming two low nodes at the posterior edge of the two principal plates composing it. It is edged by the narrow, bare, posterior lateral ambulacra, which extend till they meet the subanal plastron, then diverge following the line of the plastron and are lost in the tuberoles before reaching the edge of the test.

The subanal plastron is broad, heart-shaped, occupying nearly the whole of the posterior part of the sloping actinal surface of the test. It is edged by a very broad fasciole, broadest at the posterior edge, sending off a narrow anal branch which remains open, but extends to the abactinal surface above the anal system. The anal system, situated in the upper part of the depression of the test, is elliptical longitudinally, pointed above and below; the posterior part of the subanal fasciole is on the edge of the depression of the test in which the anal system is placed.

The peripetalous fasciole forms across the posterior interambulacrum and the posterior lateral interambulacral space an open rectangle with rounded corners and slightly undulating sides. The width of the fasciole equals in breadth the median interporiferous space of the posterior petals. It forms a right angle parallel to the anterior

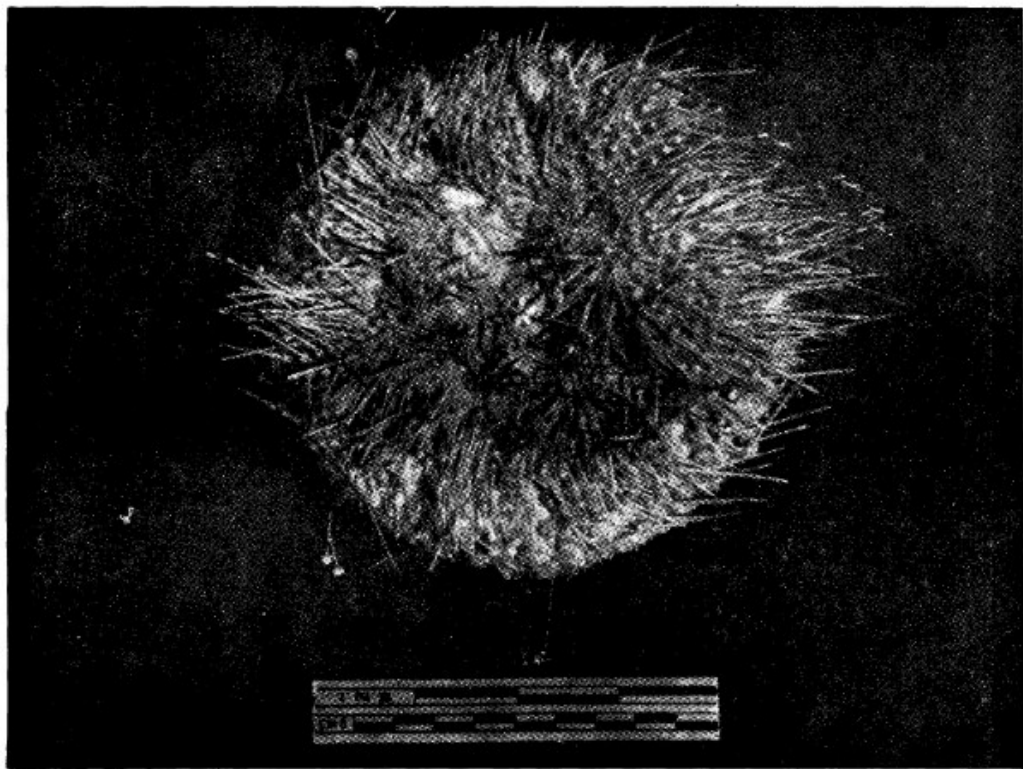


Fig. 21. *Astropyga radiata* (Leske).
(Dorsal view).

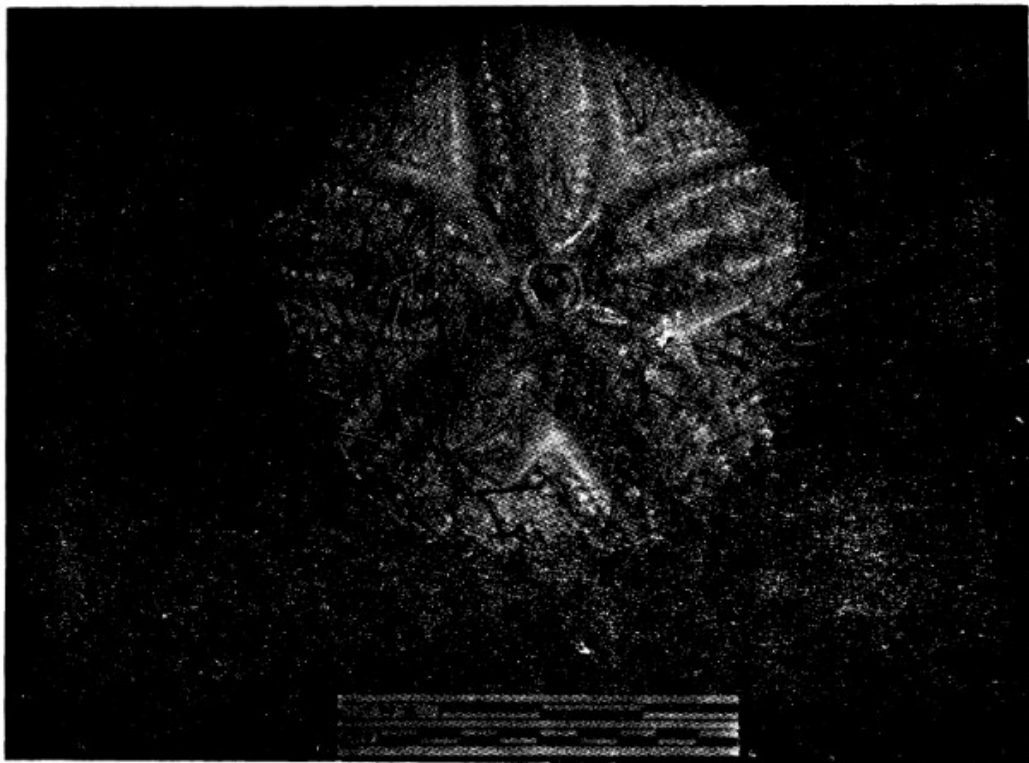


Fig. 22. *Astropyga radiata* (Leske).
(Ventral view).

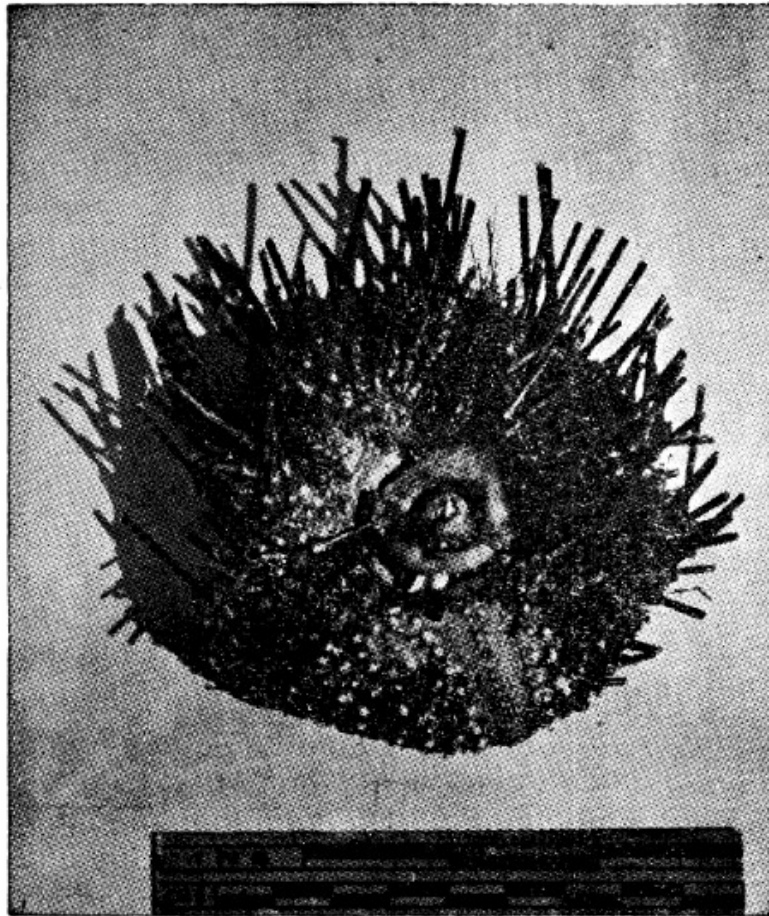


Fig. 23. *Echinothrix calamaris* (Pallas).

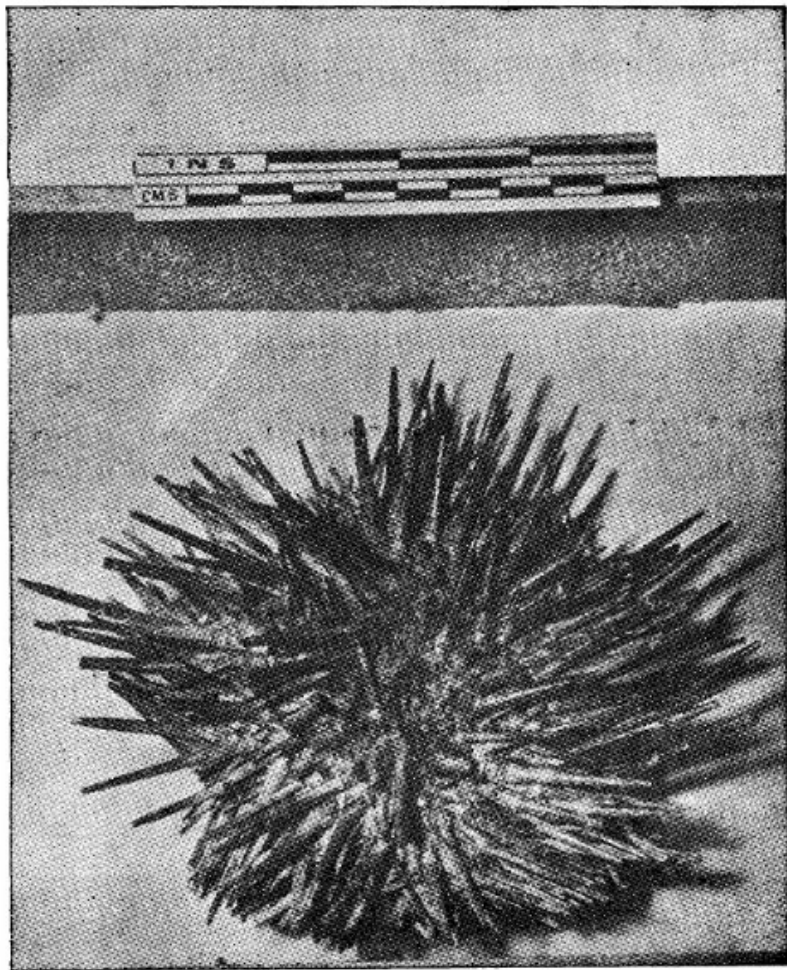


Fig. 24. *Stomopneustes variolaris* (Lamarck).
(Dorsal view, with spines intact).

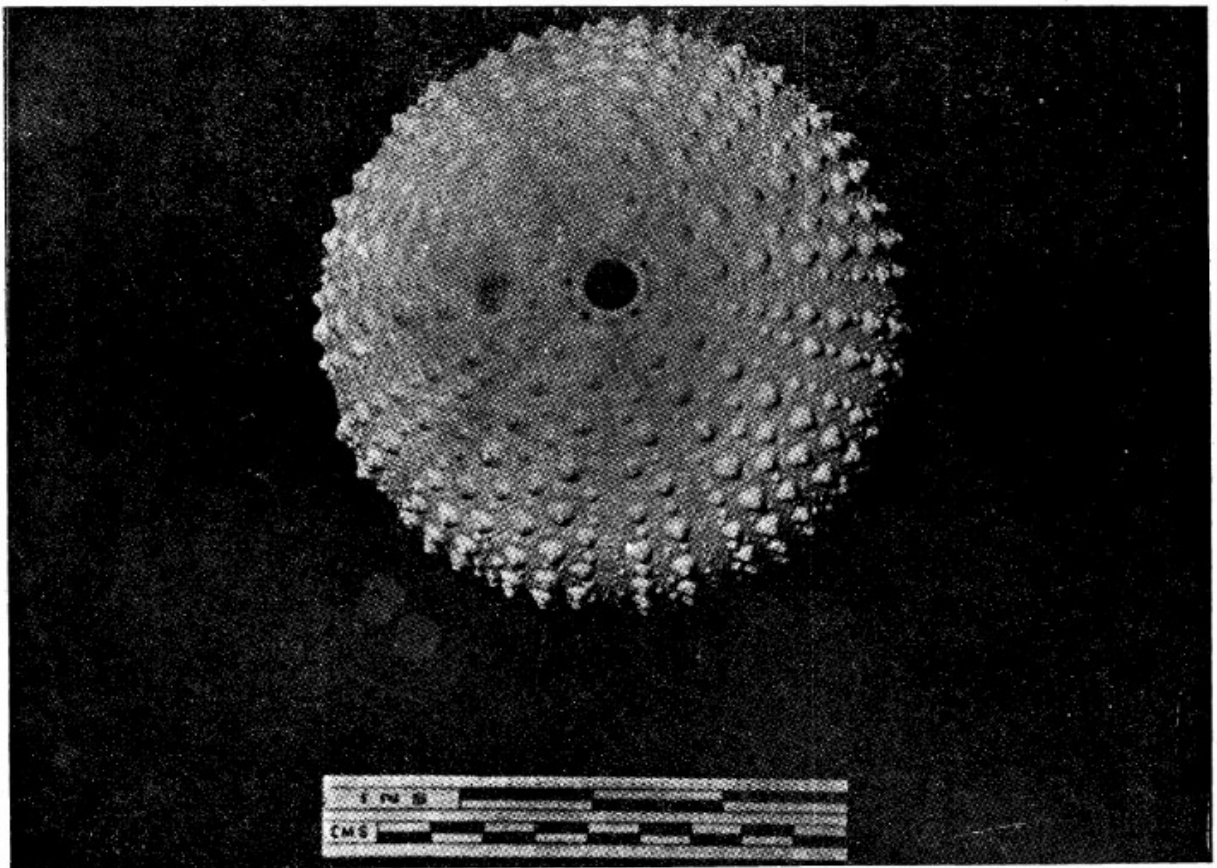


Fig. 25. *Stomopneustes variolaris* (Lamarck).
(Dry-preserved test, without spines: Dorsal view).

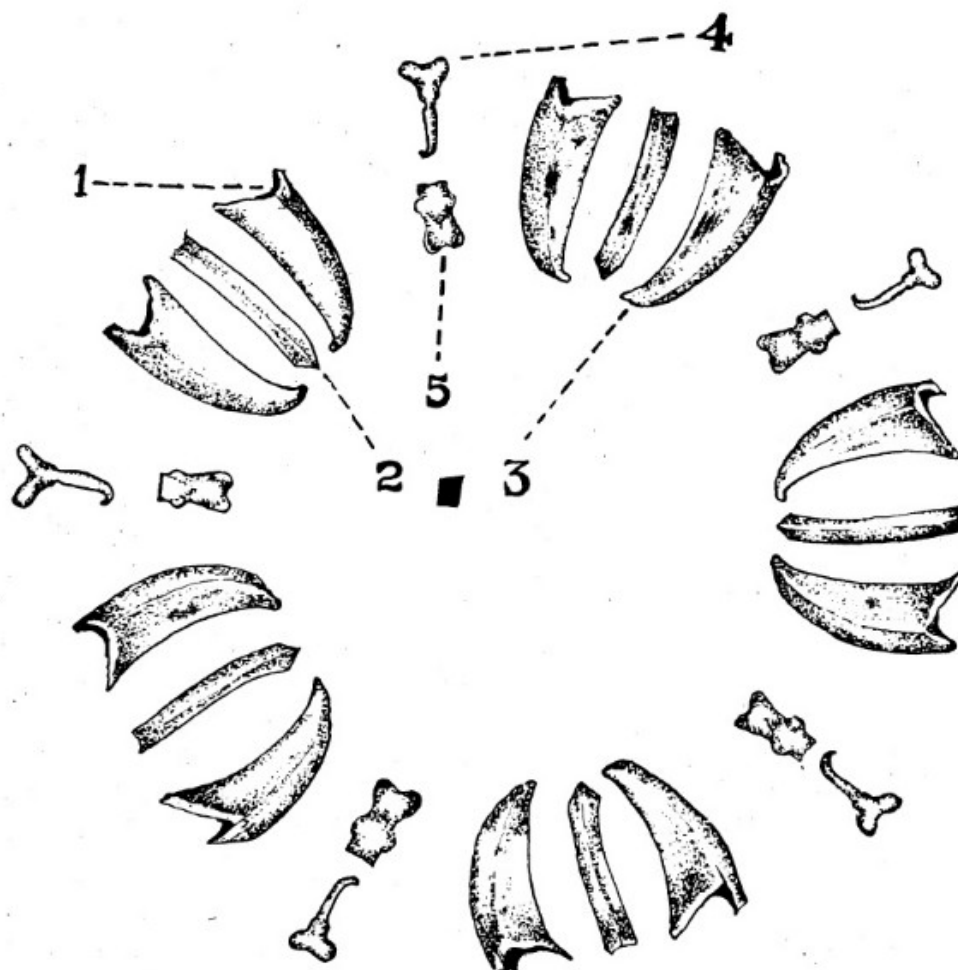


Fig. 26. "Aristotle's lantern"
(Masticatory apparatus of Sea-urchin)

Stomopneustes variolaris (Lamarck).
(Disarticulated).

- 1- Epiphysis
- 2. Tooth: Inter-radial
- 3. Alveolus
- 4. Compass: Radial
- 5. Rotula.

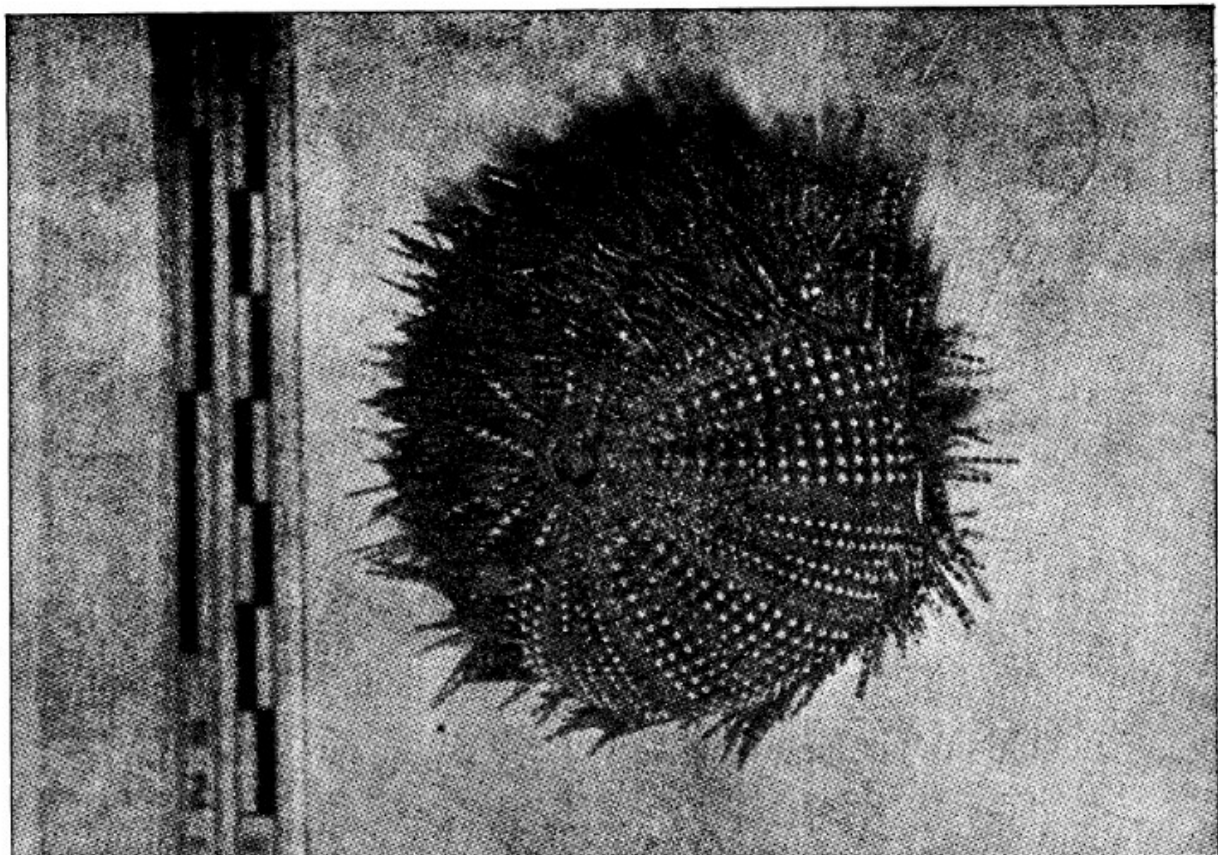


Fig. 27. *Salmacis bicolor* Agassiz.
(Dorsal view : with spines).

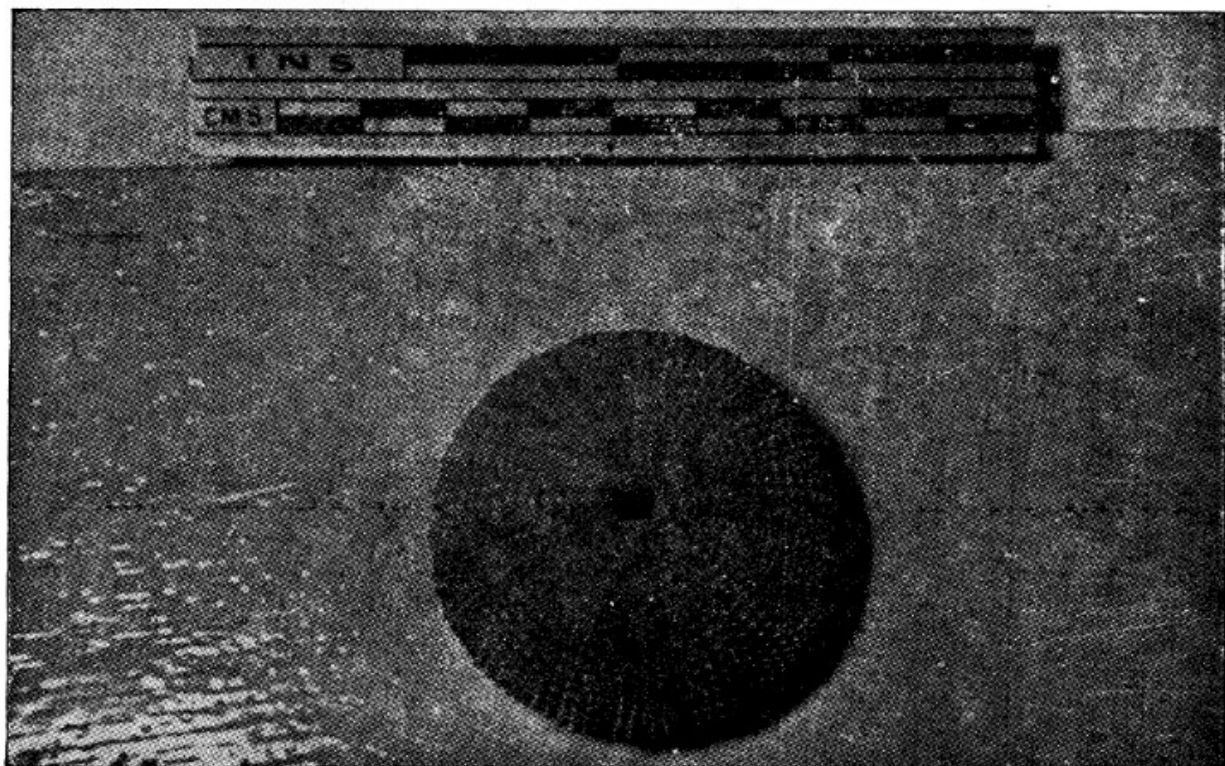


Fig. 28. *Salmacis bicolor* Agassiz.
(Dorsal view : without spines).

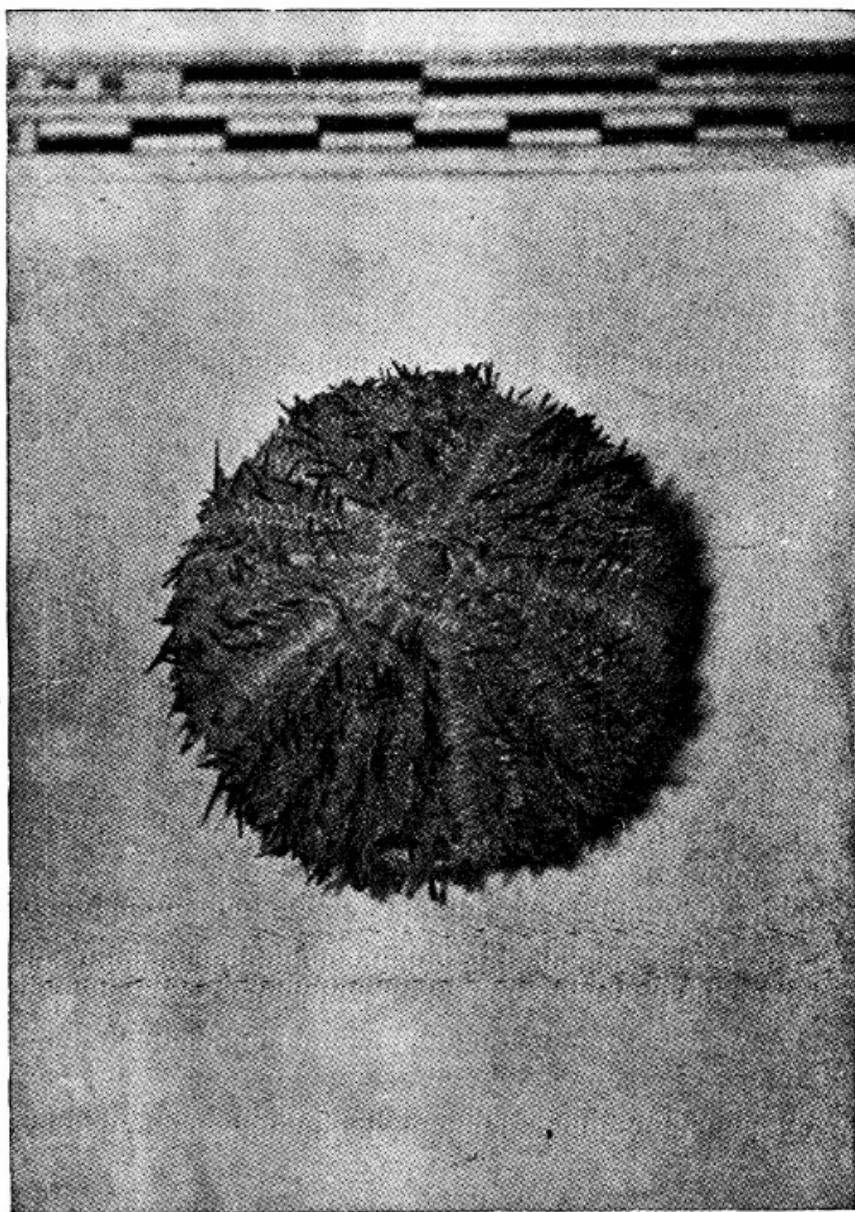


Fig. 29. *Salmacis virgulata* Agassiz & Desor.
(Wet-preserved specimen : Dorsal view).

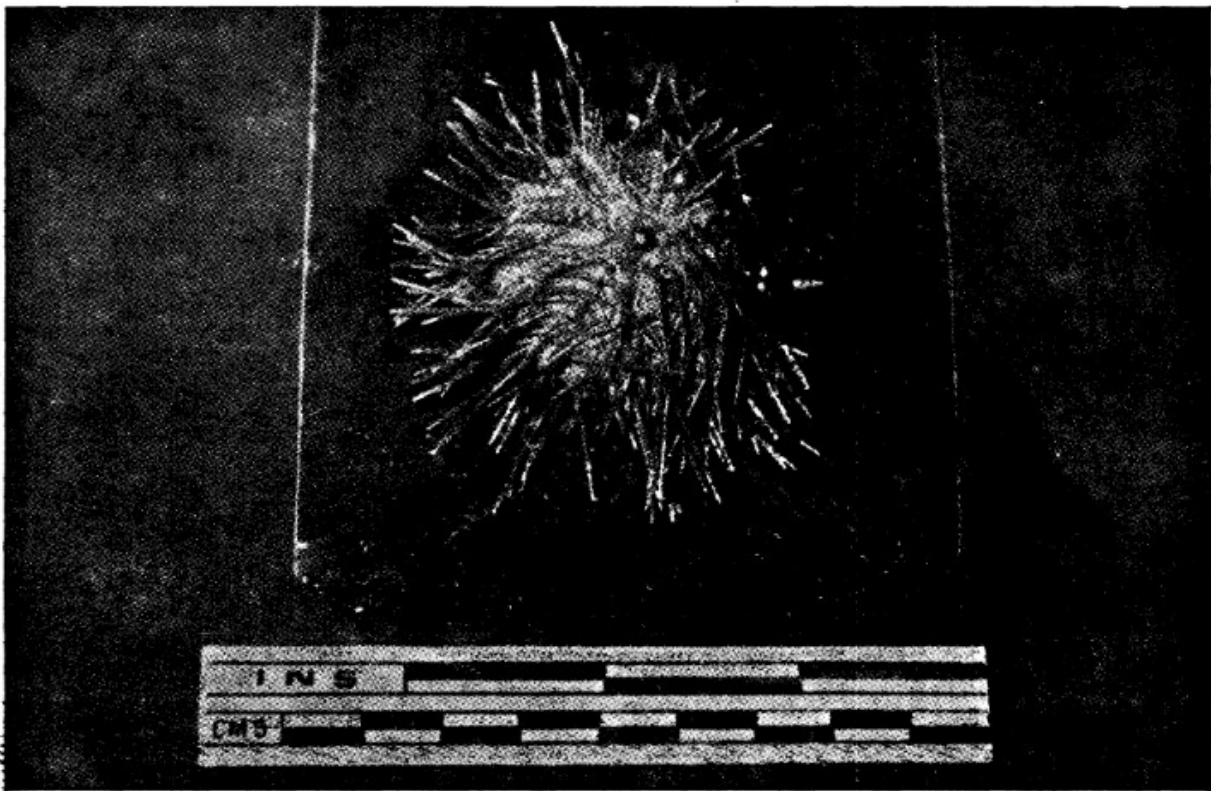


Fig. 30. *Temnopleures toreumaticus* (Leske).
(Wet-preserved specimen : Dorsal view).

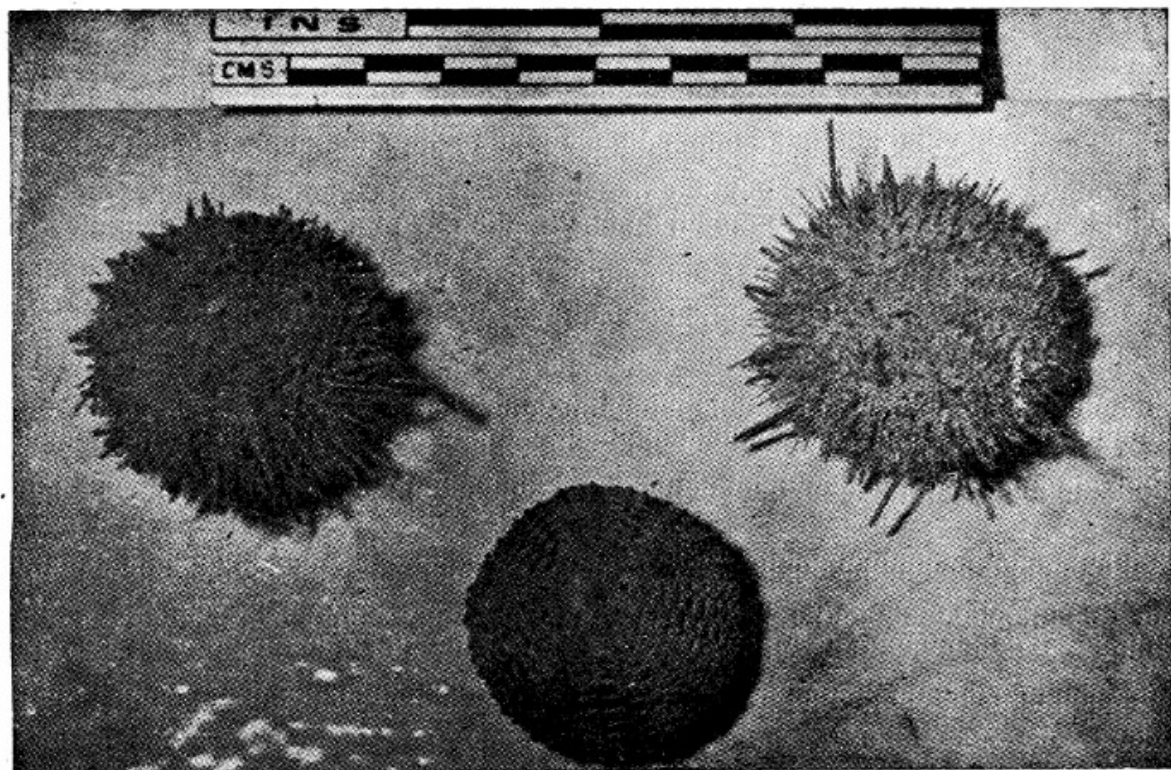


Fig. 31. *Temnopleurus toreumaticus* (Leske).
(Dry-preserved specimens : with and without spines).

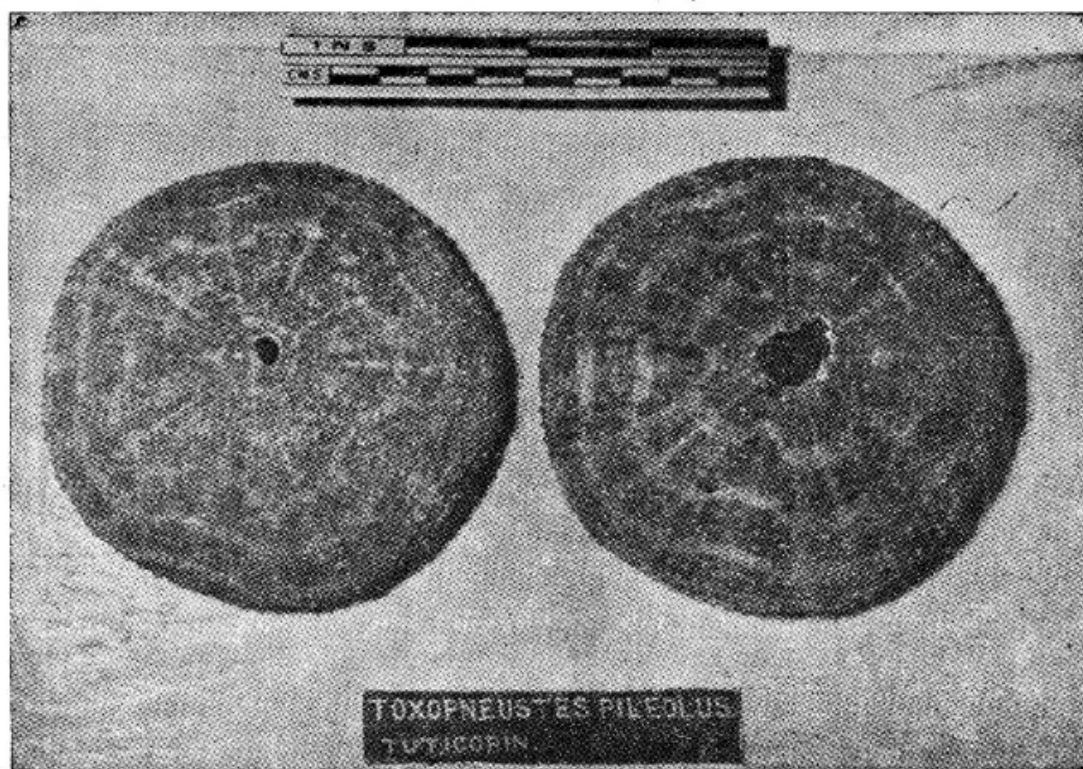


Fig. 32. *Toxopneustes pileolus* (Lamarck).
(Dorsal view of the test).

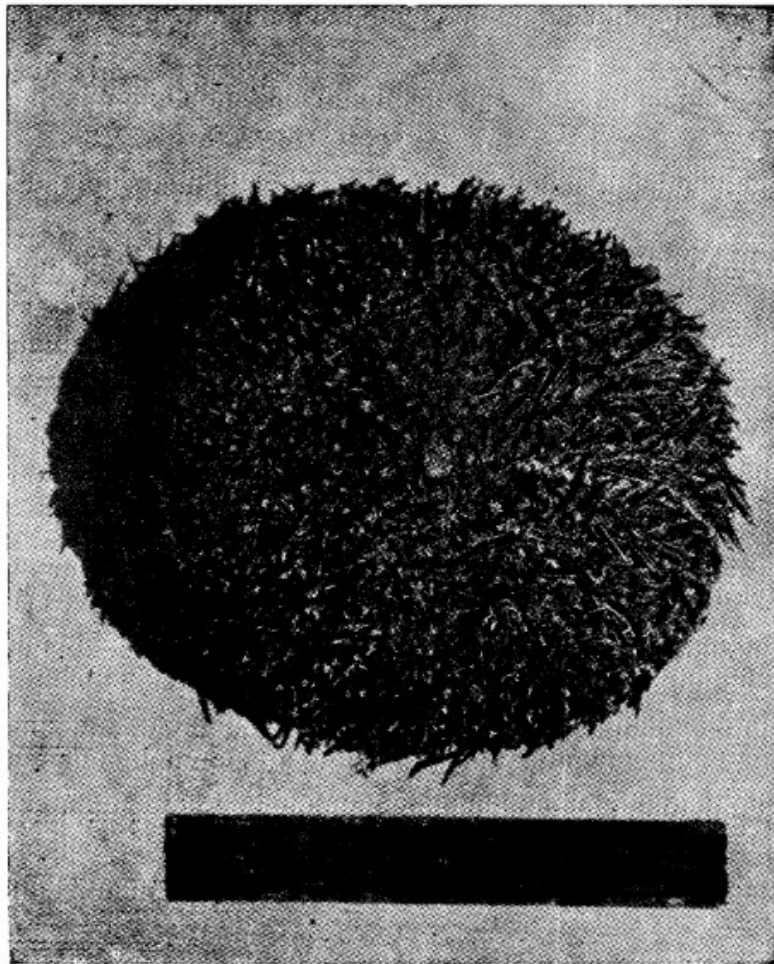


Fig- 33- *Tripneustes gratilla* (Linné).
(Dorsal view).

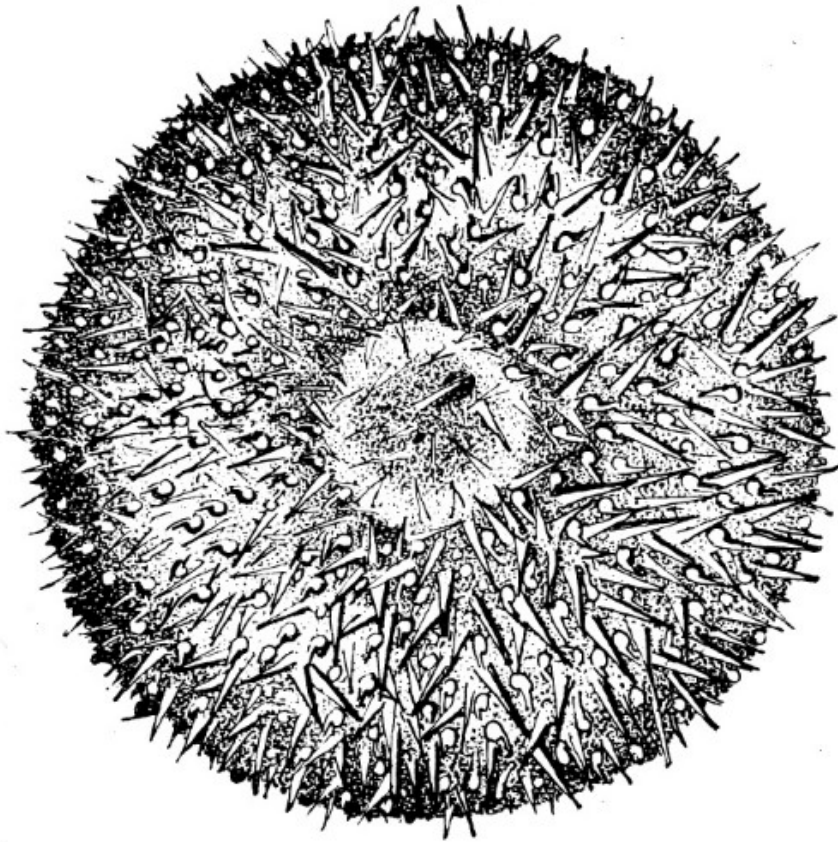


Fig. 34. *Gymnechinus robillardi* (de Lorient).
(Dorsal view) ($\times 5$).

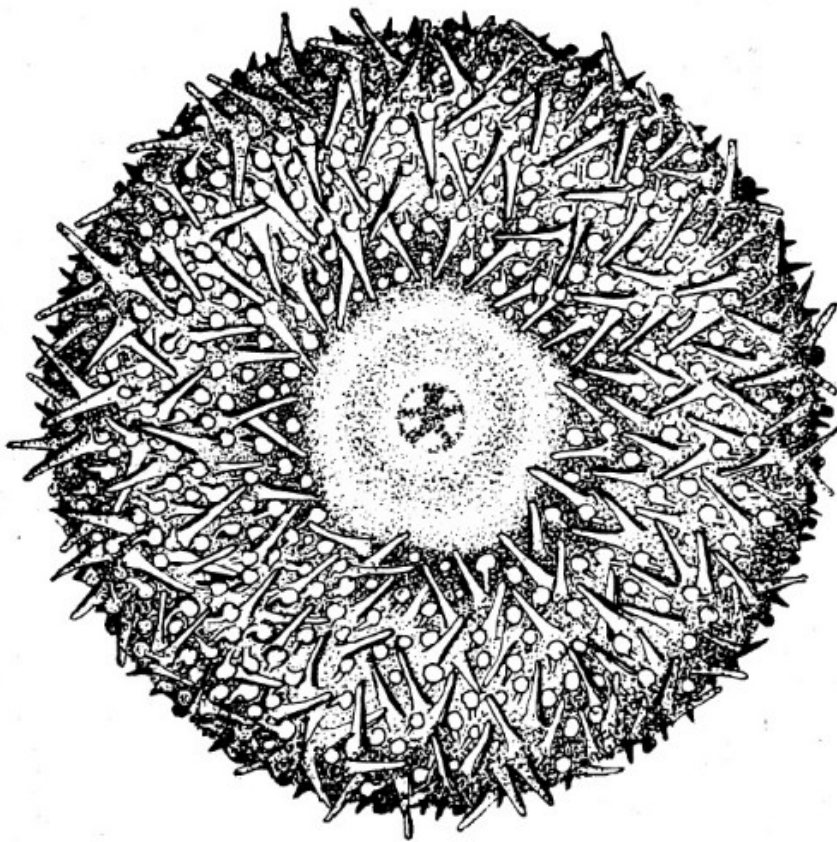


Fig. 35. *Gymnechinus robillardi* (de Loriol).
(Ventral view) ($\times 5$).

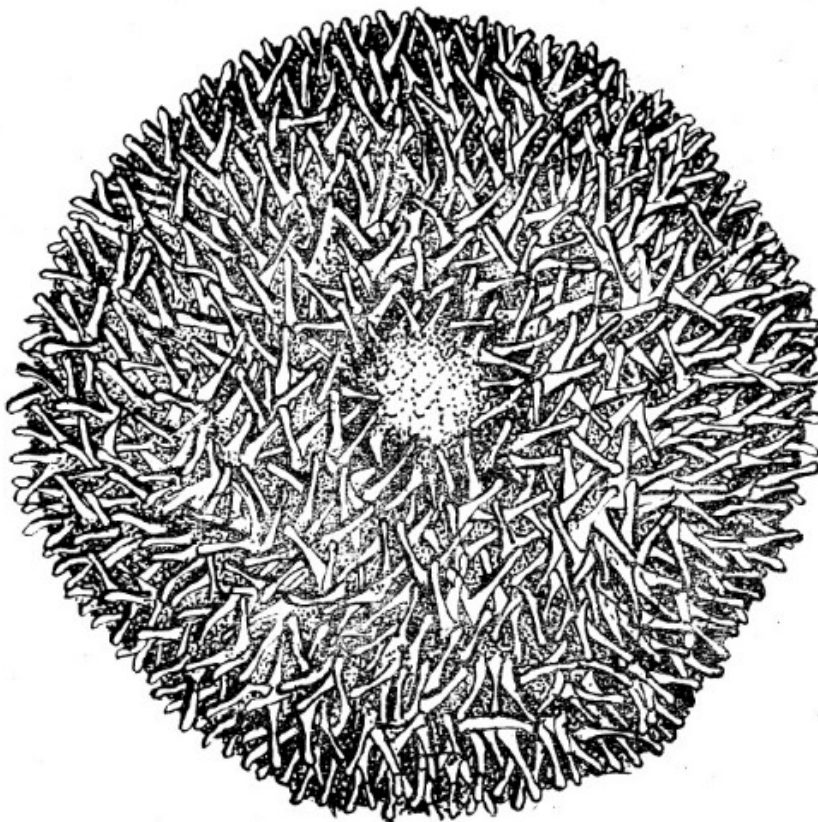


Fig. 36. *Parechinus angulosus* (Leske).
(Dorsal view) ($\times 4$).

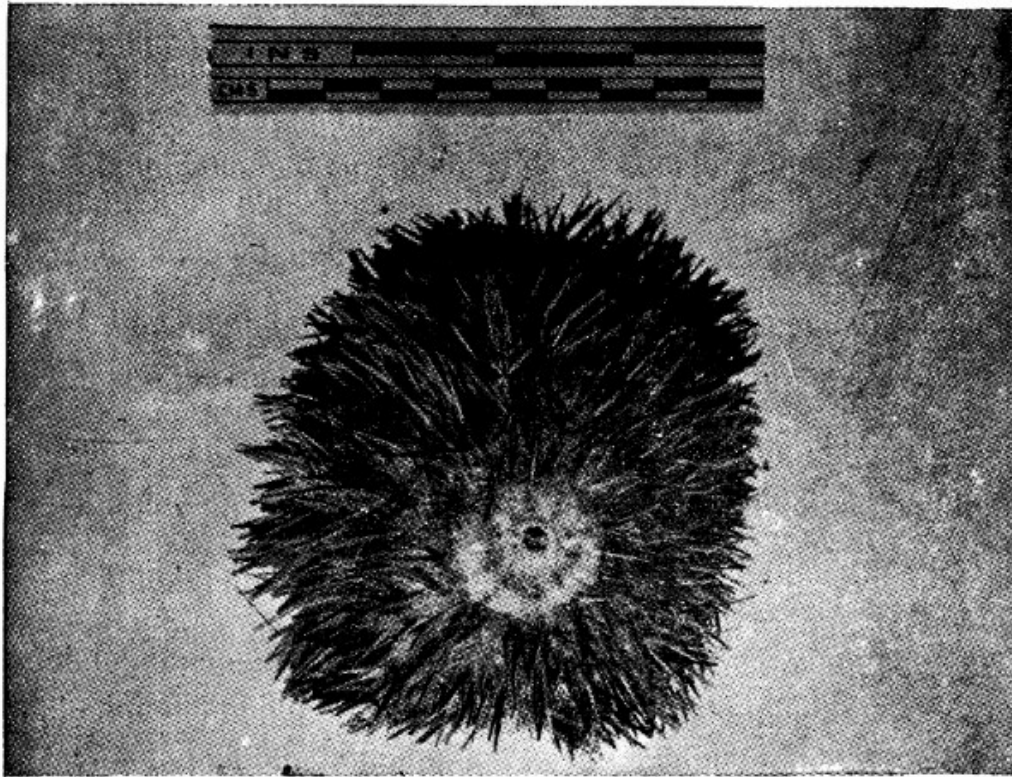


Fig 37. *Pseudoboletia indiana* (Michelin).
(Dorsal view).

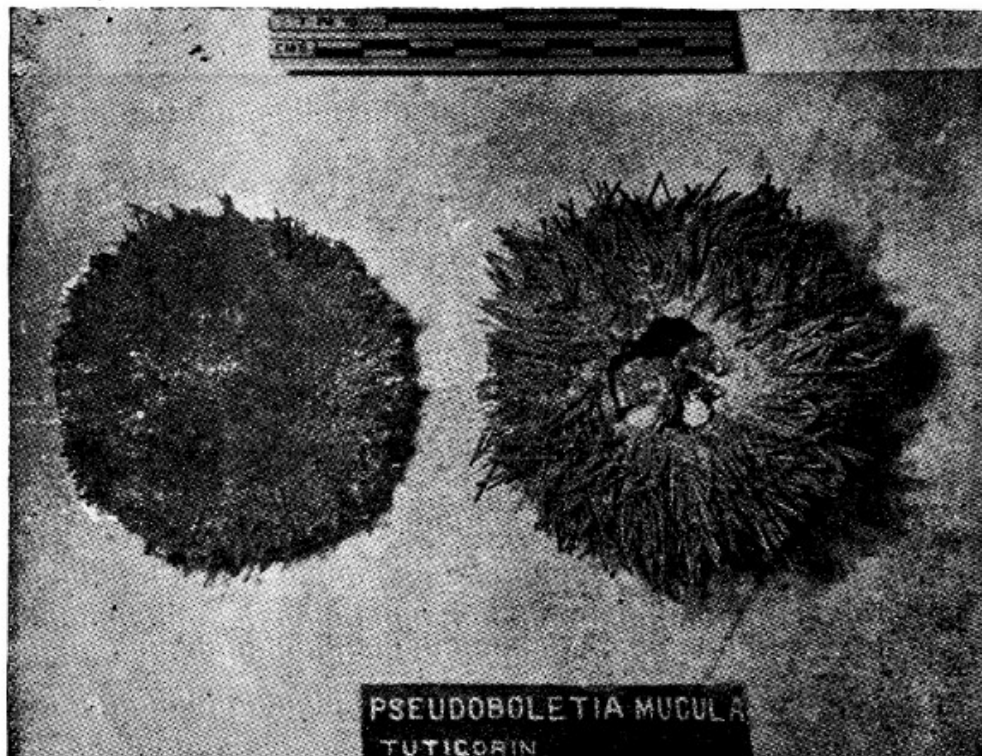


Fig. 38. *Pseudoboletia maculata* (Troschel).
(Left : Dorsal view ; Right : Ventral view).

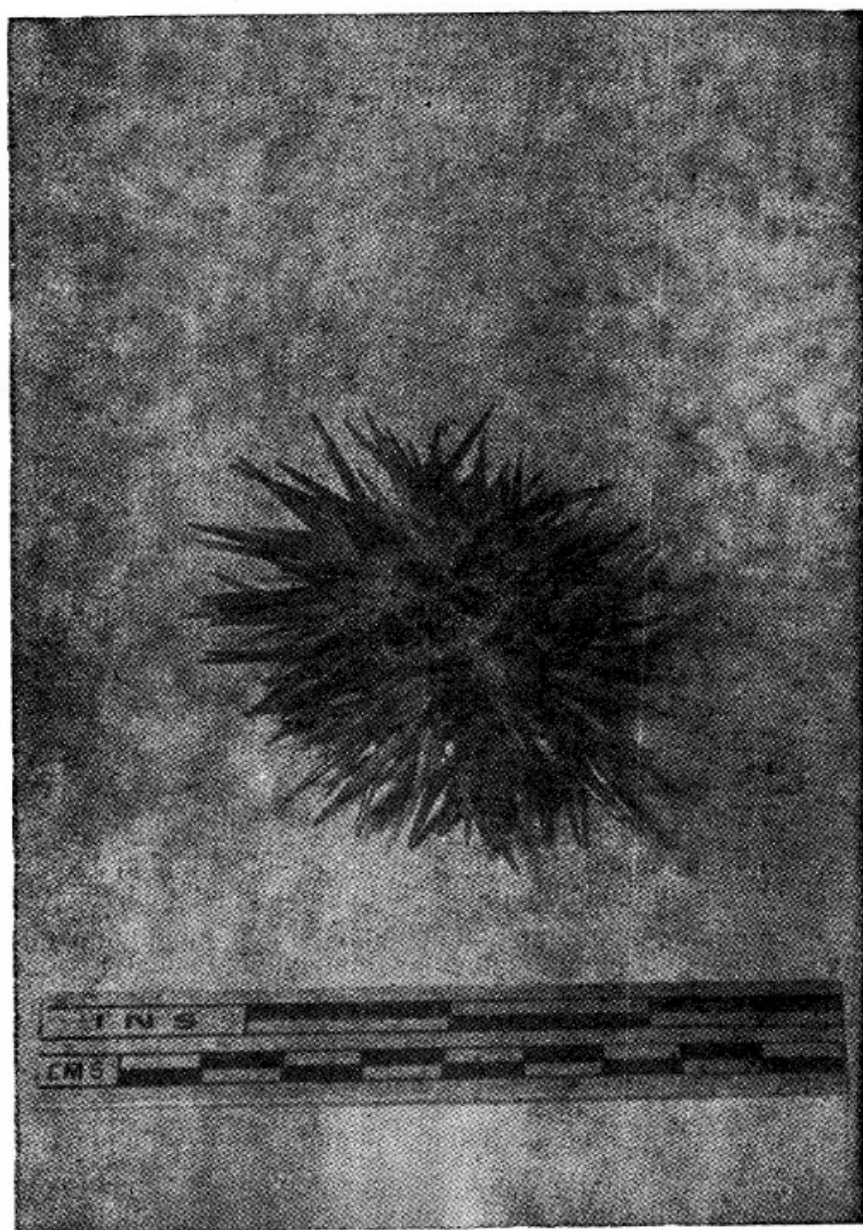


Fig. 39. *Echinometra mathaei* (de Bialville).
(Dorsal view).

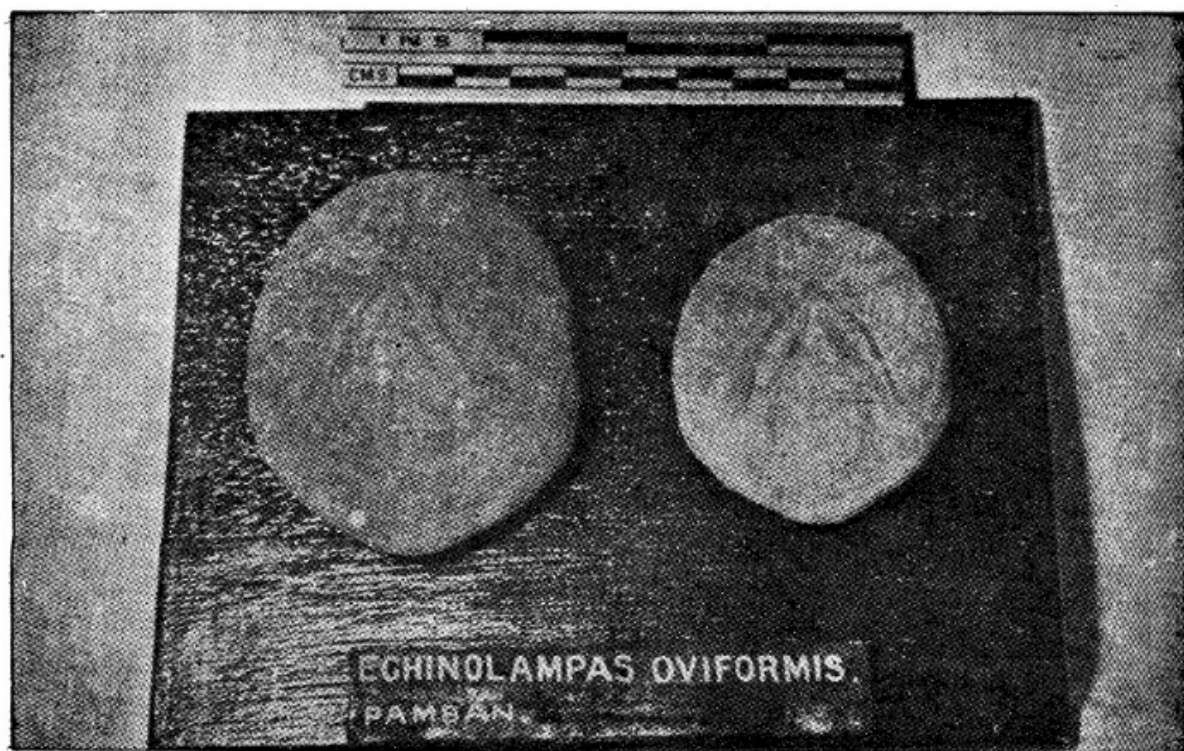


Fig. 40. *Echinolampas ovata* (Leske).
(Dorsal view).

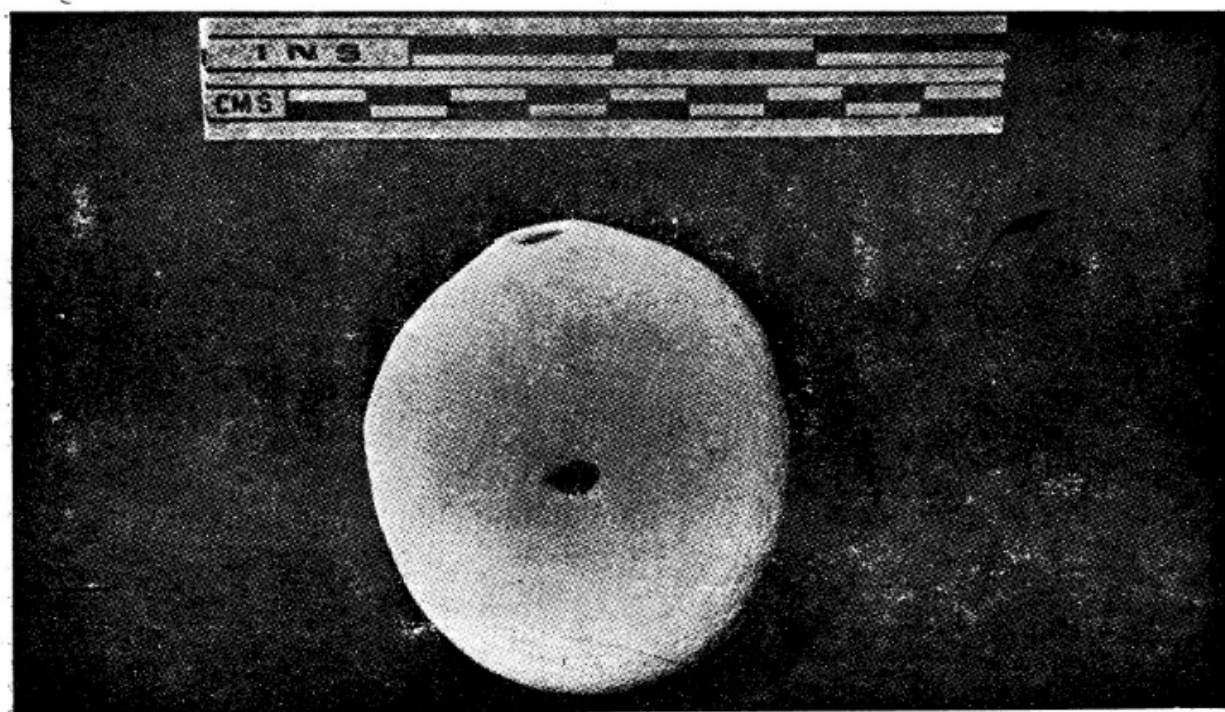


Fig. 41. *Echinolampas ovata* (Leske).
(Ventral view).

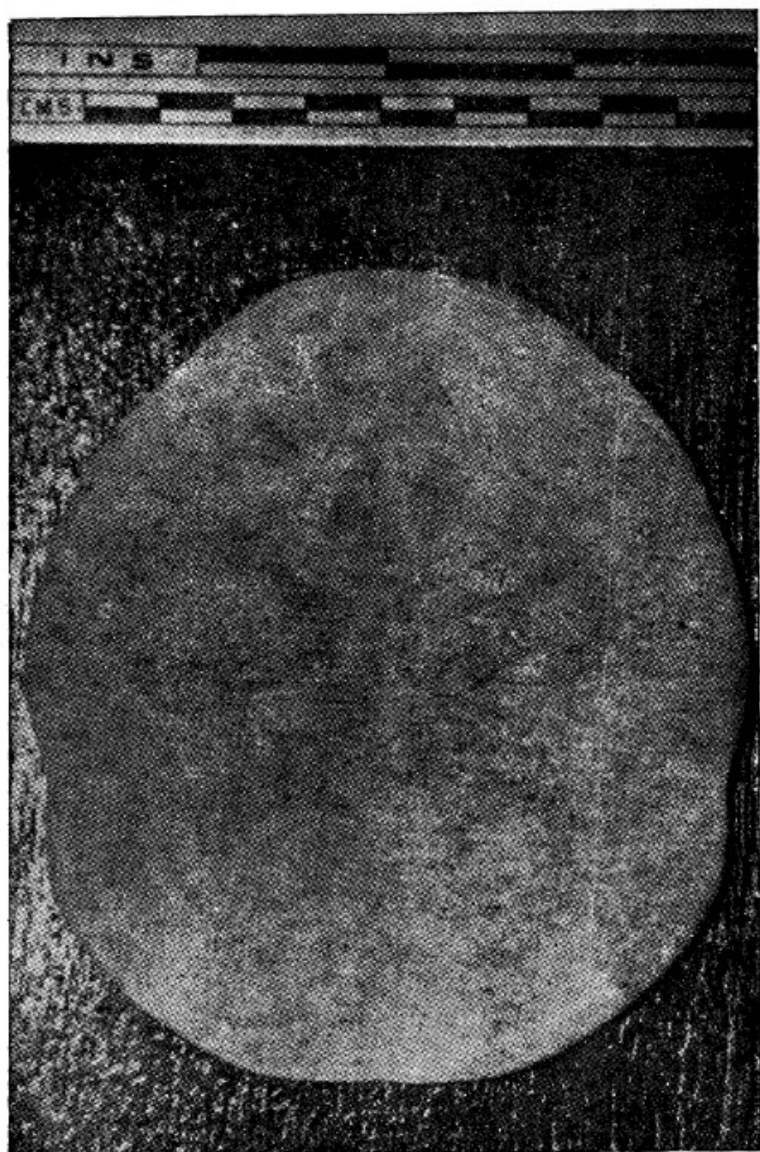


Fig. 42. *Clypeaster humilis* (Leske).
(Dorsal view).

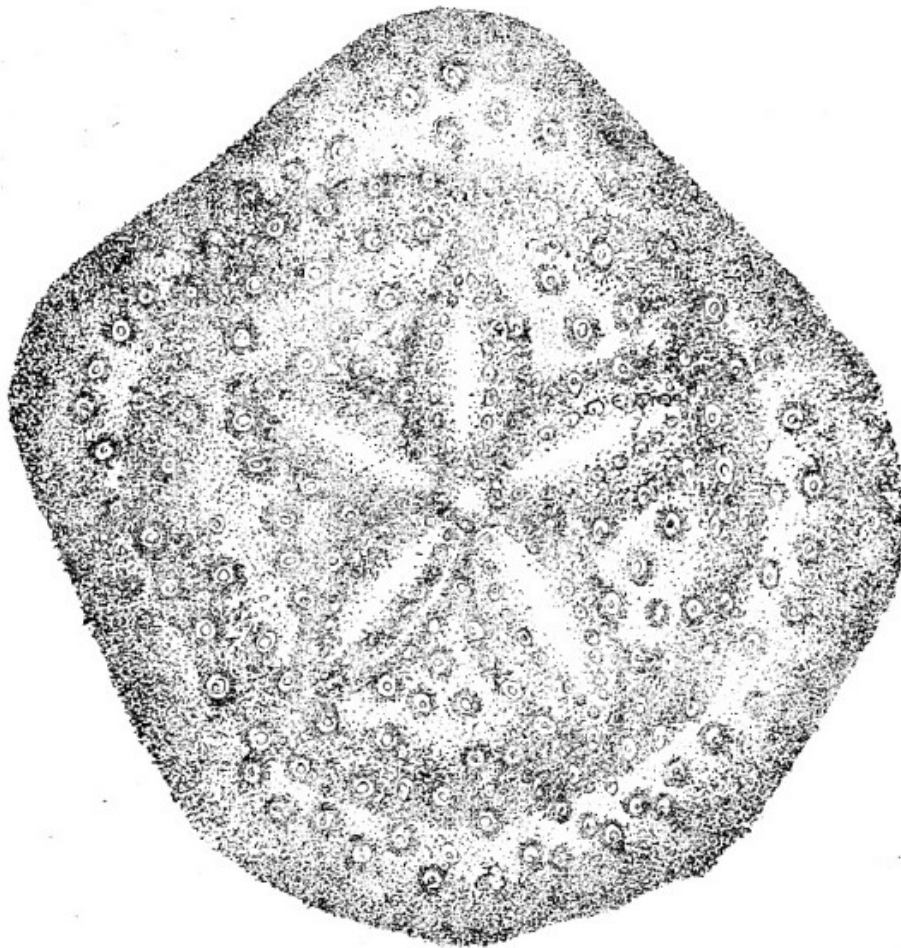


Fig. 43. *Clypeaster rarispinus* (Meijere).
(Dorsal view) ($\times 4$).

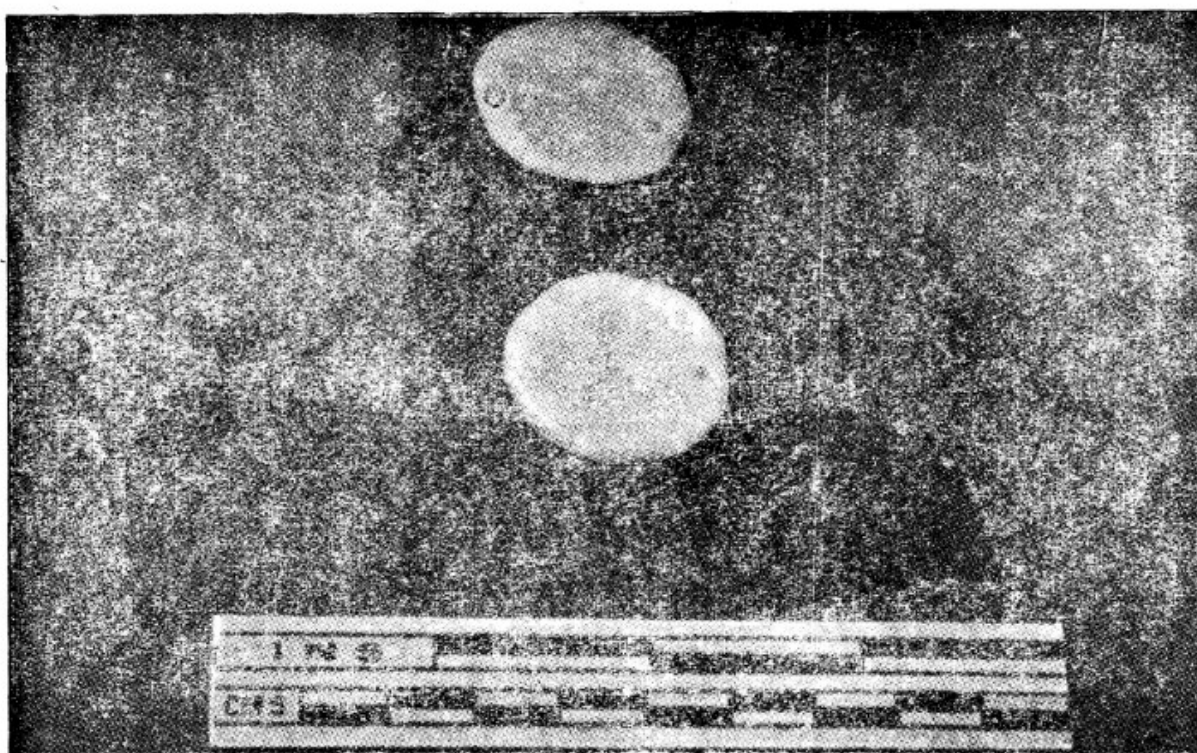


Fig. 44. *Laganum decagonale* (De Blainville).
(Above : Ventral view; Below : Dorsal view).

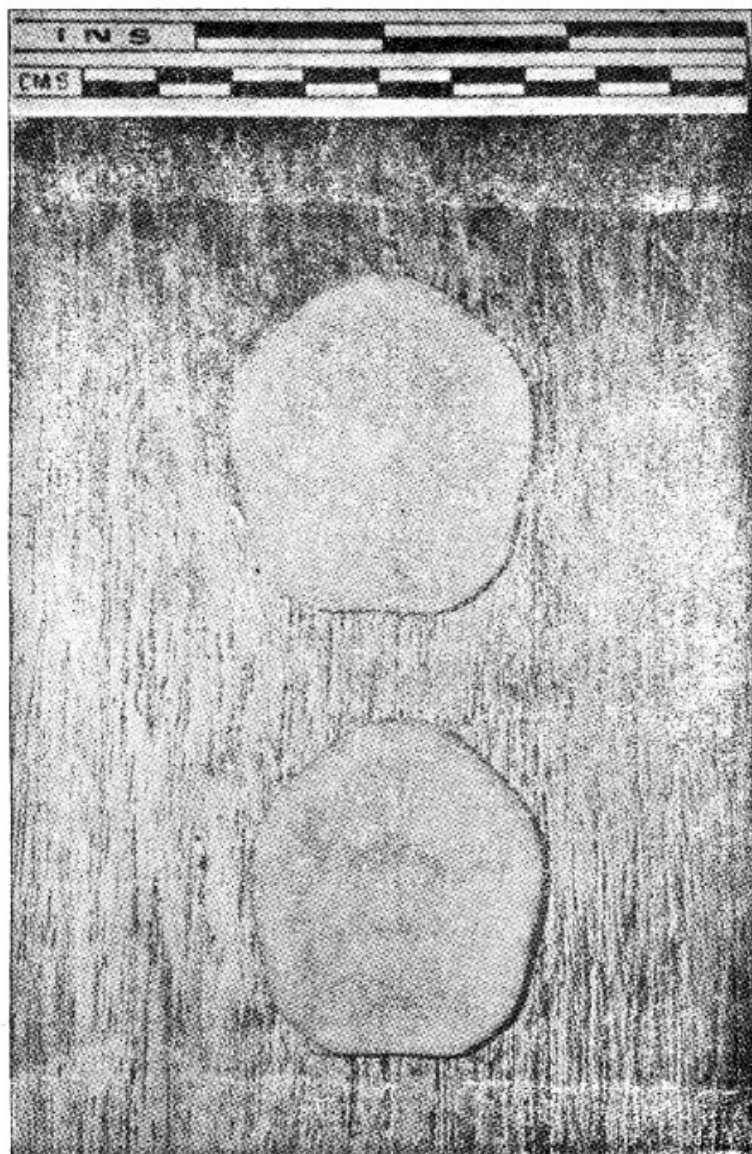


Fig. 45. *Laganum depressum* (Lesson).
(Above : Ventral view; Below : Dorsal view).

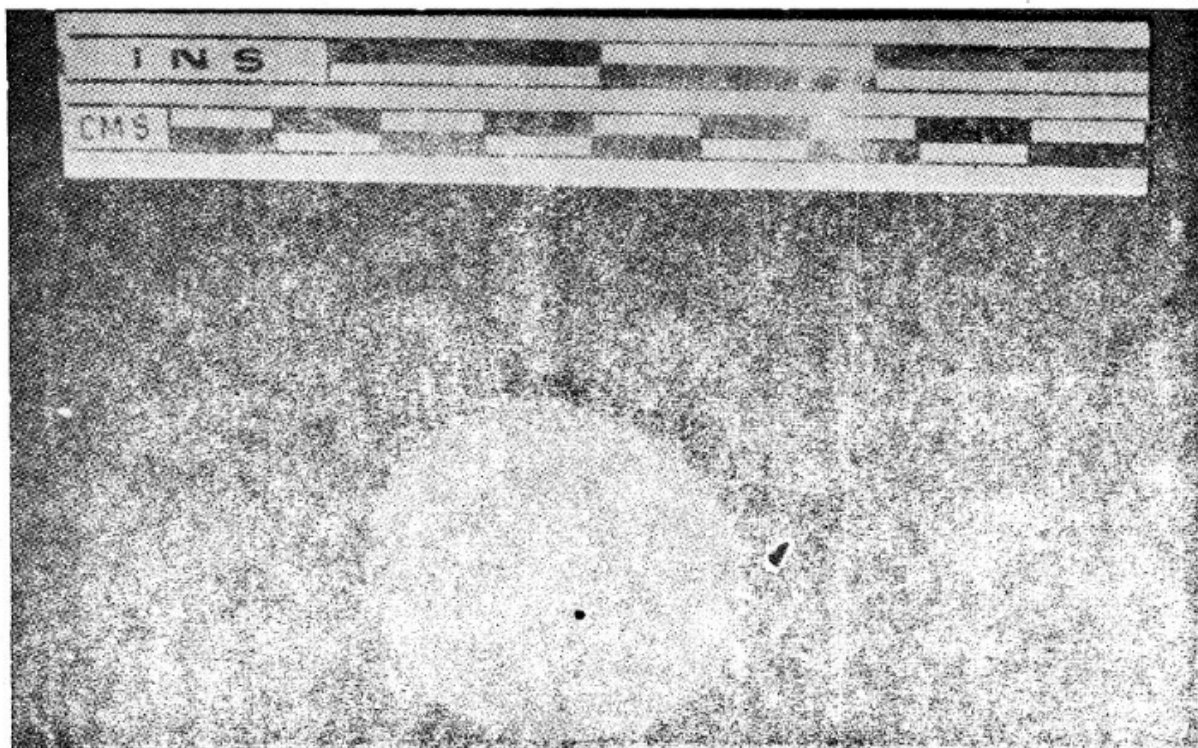


Fig. 46. *Peronella lesueurii* (L. Agassiz).
(Dorsal view).

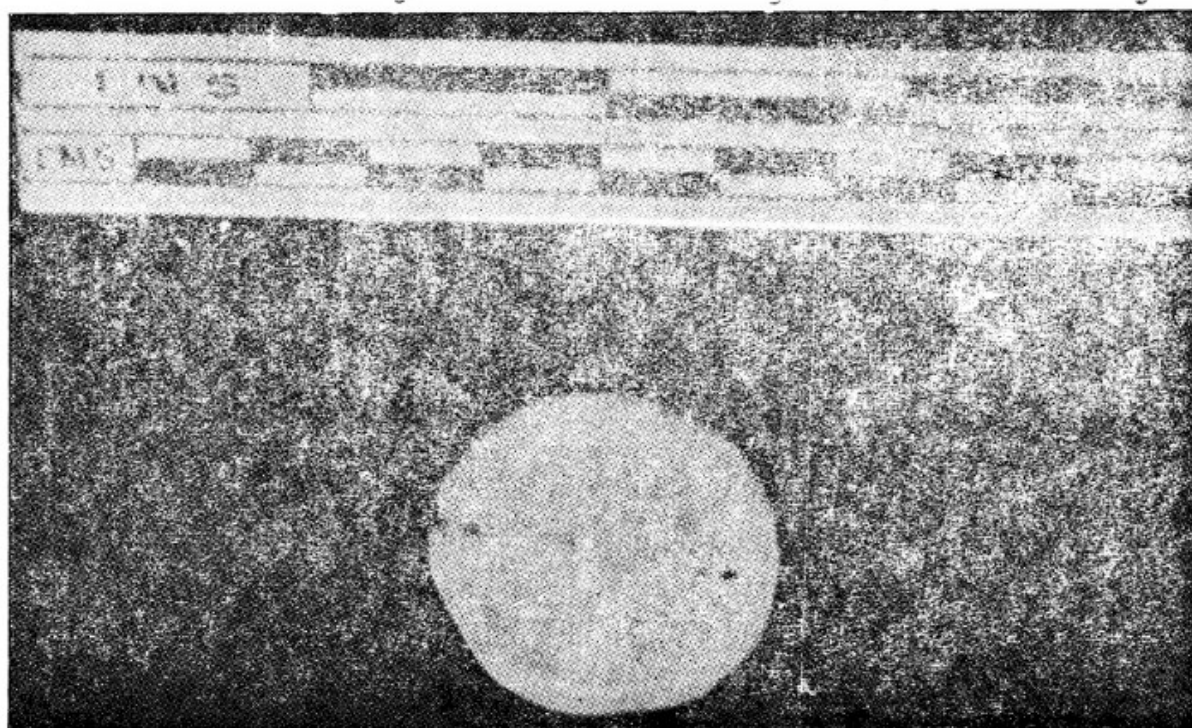


Fig. 47. *Peronella orbicularis* (Leske).
(Dorsal view).

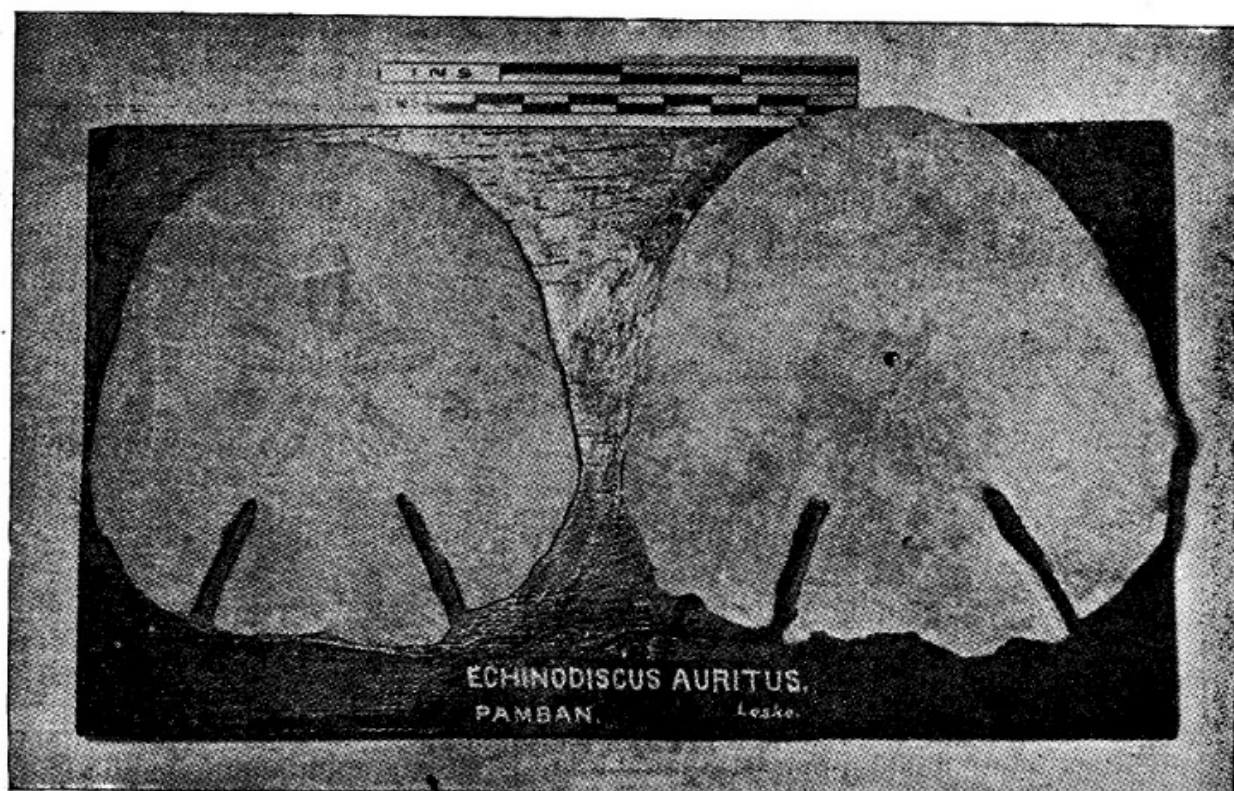


Fig. 48. *Echinodiscus auritus* (Leske).
(Left : Dorsal view; Right : Ventral view).

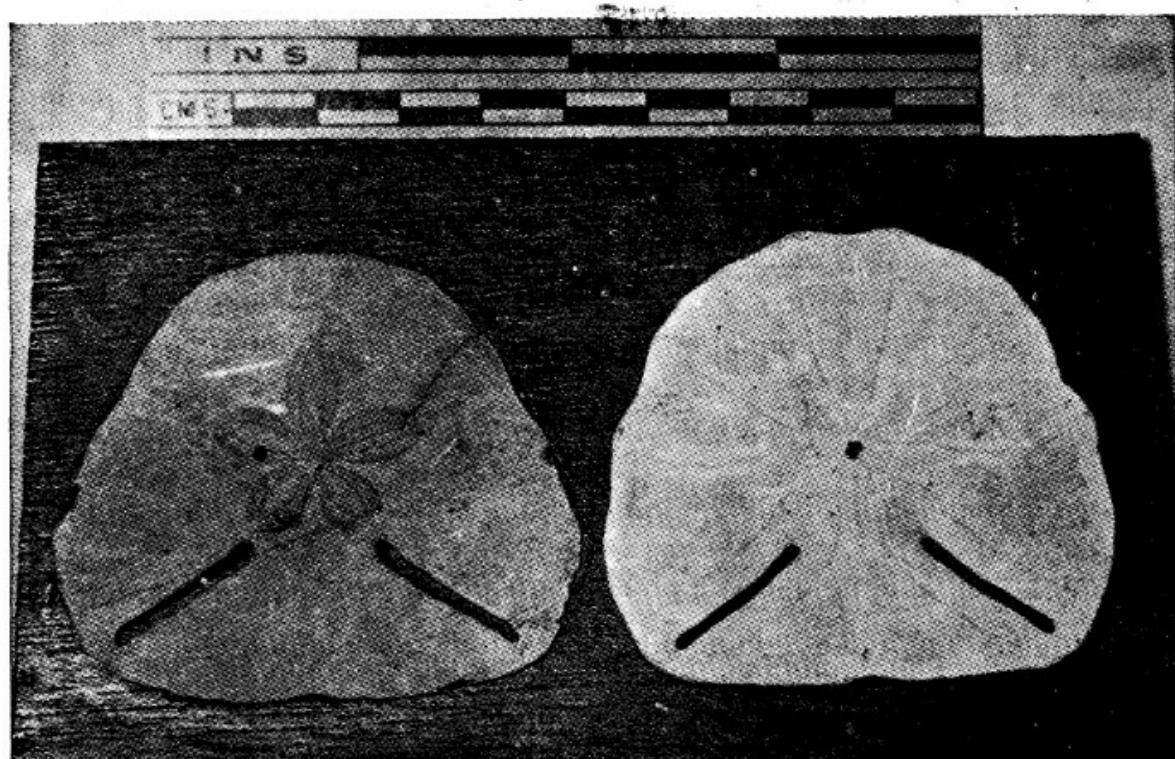


Fig. 49. *Echinodiscus bisperforatus* (Leske).
(Left : Dorsal view; Right : Ventral view).

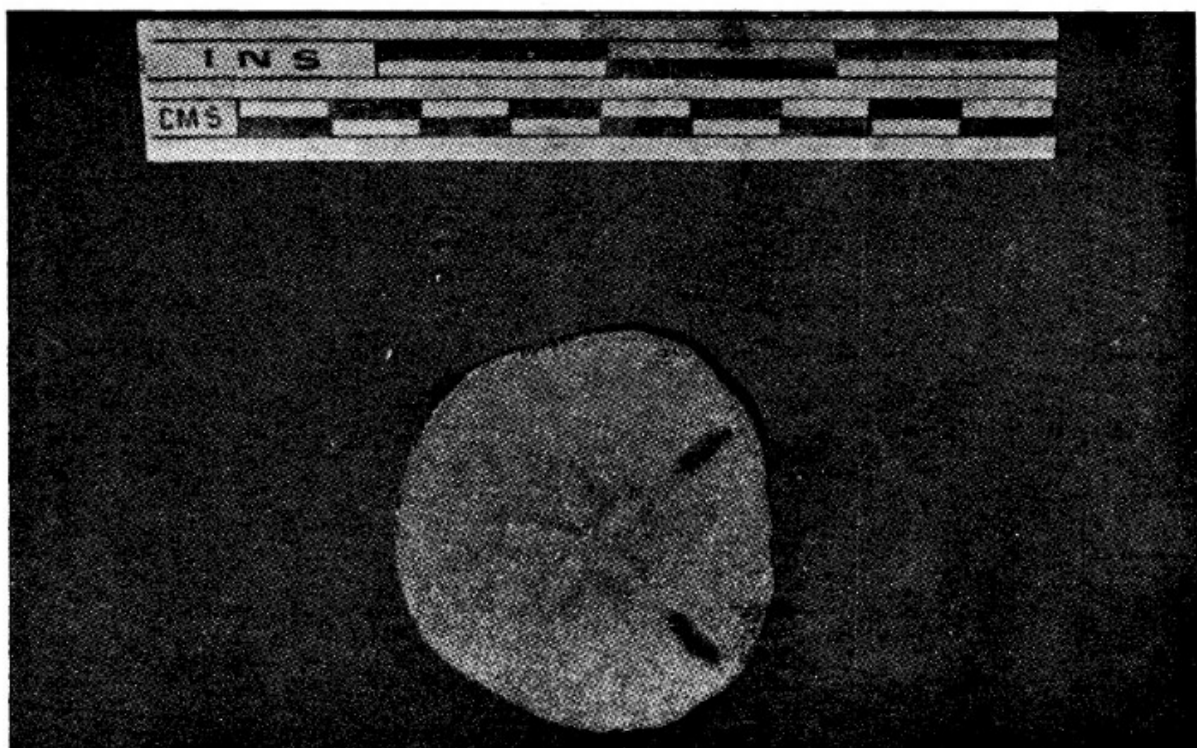


Fig. 50. *Echinodiscus bisperforatus* (Leske).

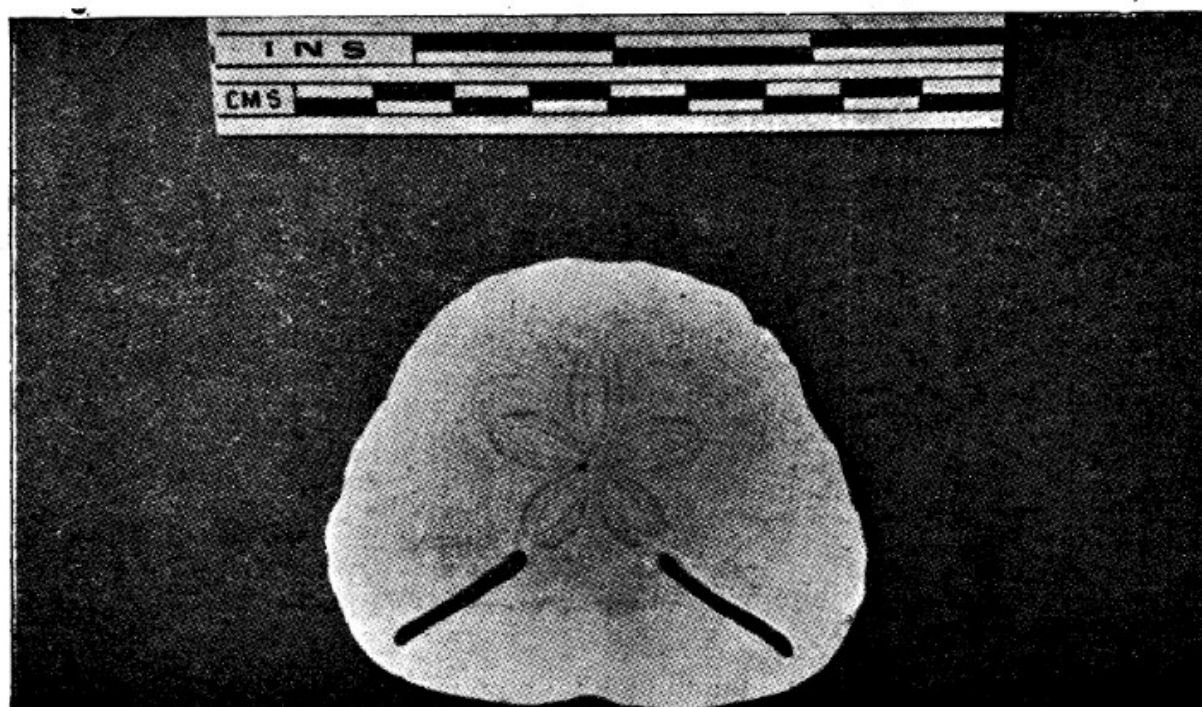


Fig. 51. *Echinodiscus bisperforatus* var. *truncatus* (Agassiz).
(Dorsal view : Wet-preserved specimen).

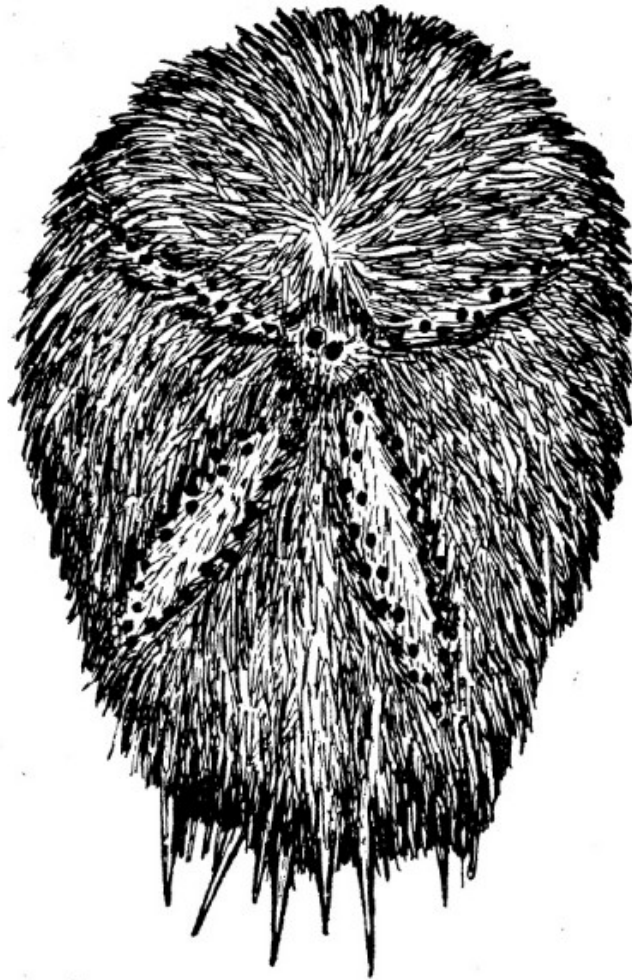


Fig. 52. *Pseudomaretia alta* (Agassiz).
(Dorsal view) ($\times 4$).

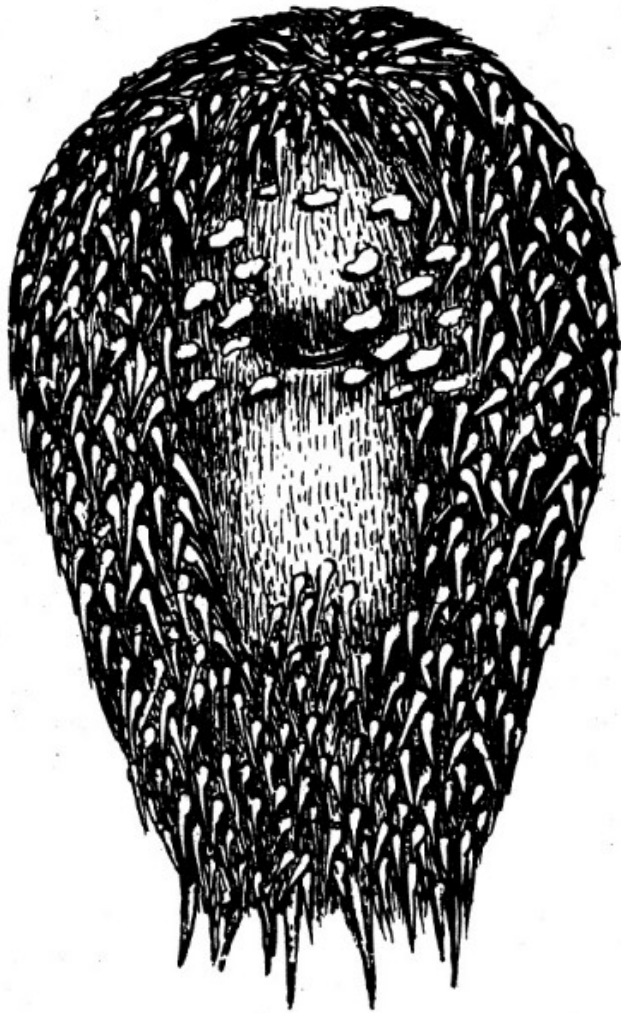


Fig. 53. *Pseudomaretia alta* (Agassiz).
(Ventral view) ($\times 4$).



Fig. 54. *Lovenia elongata* (Gray).
(Tests with spines)
(Left : Dorsal view : Right : Ventral view).



Fig. 55. *Lovenia elongata* (Gray).
(Tests with the spines removed).
(Left : Dorsal view : Right : Ventral view).

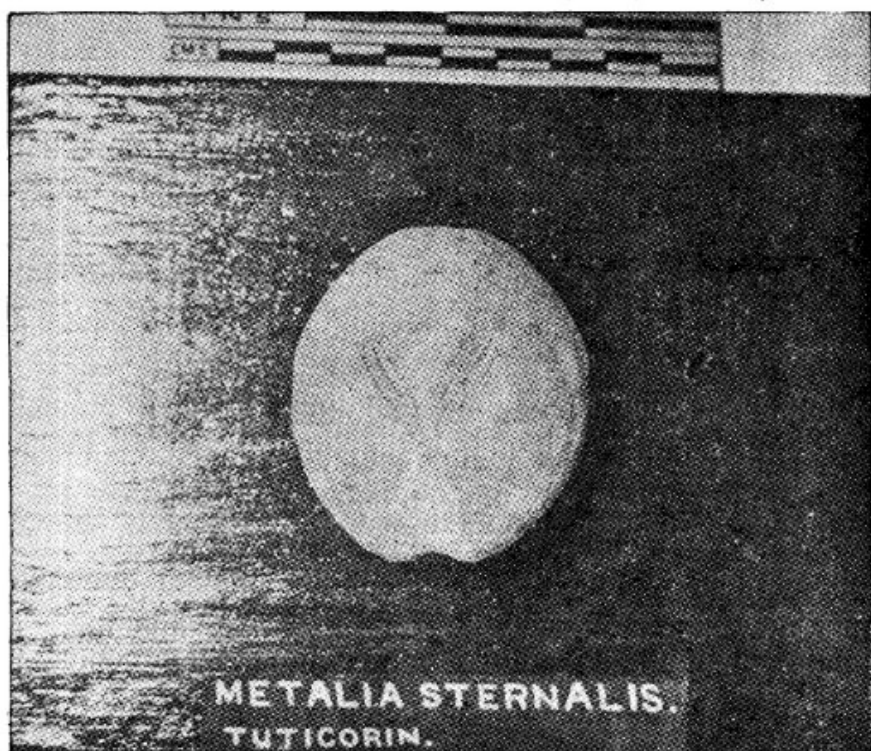


Fig. 56. *Metalia sternalis* (Lamarck).
(Dorsal view of dry-preserved test).

petals, at a short distance from it, and then runs diagonally towards the extremity, which it crosses at right angles to the trend of the petal, then diverges at the same angle on the other side of the petal, forming a deep, re-entering angle in the anterior lateral interambulacra. It then runs obliquely towards the ambulacral furrow, and at a distance from it runs at a smaller angle towards the median line of the odd ambulacrum. The actionostome (peristome) is transverse; the phyllodes are well developed.

With the exception of the short diagonal rows of somewhat large tubercles along the edges of the petals and of the odd ambulacrum; within the peripetalous fasciole, the whole abactinal part of the test is covered by small, distinct tubercles, perforate and crenulate, with large, flat, indistinct, scrobicular circles, and but few miliaries scattered in between. On the actinal (oral) side the tubercles increase rapidly in size towards the ambulacra where they attain the greatest size, and are quite distant; the tubercles of the actinal plastron diminish rapidly from the edge to the median keel.

The tubercles of the posterior part of the subanal plastron increase in size from the outer edge; they run in curved radiating lines towards the middle transverse line, from which the rows of tubercles radiate towards the anterior edge, becoming smaller, and forming more numerous rows as they approach the fasciole, between the deeply sunken pores, which are placed adjoining the fasciole, and from which slight grooves extend between the radiating rows of tubercles. The larger specimens show, perhaps better than in any other Spatangoid, that the pores of the subanal plastron are formed by the posterior poriferous zones of the posterior lateral ambulacra.

In smaller specimens of this species, which have been described as *Xantholi Garatti*, the test is more globular and swollen. The outline of the posterior interambulacrum is regularly arched, the posterior extremity vertically truncated, the posterior petals arched outwards, and only a small part of the abactinal part of the posterior zone is rudimentary. The peripetalous fasciole is but slightly sinuous, and re-entering little in the lateral interambulacra. The actinal side is quite convex, and the subanal plastron is placed entirely on the vertically truncated posterior extremity. It is comparatively more diamond-shaped (rhombus-shaped) and nearly as high as broad; the broadest part of the fasciole is on the sides in this stage of growth. The spines are short, slender, cylindrical, slightly curved, of uniform size on the abactinal surface, except adjoining the edge of the petals within the peripetalous fasciole, and on the sides of the odd anterior ambulacrum. On the lower side, they are larger, but otherwise not different. They are, in dried specimens of a brilliant straw colour; in alcohol, the colour is more greyish.

Very small specimens do not differ essentially from the above; the posterior ambulacral petals are straight, well separated to the apex by the intervening interambulacral space; the posterior petals are relatively shorter, and the peripetalous fasciole scarcely forms a re-entering curve within the lateral interambulacra. The subanal plastron is as high as broad, diamond-shaped. Agassiz A., (*loc. cit.*), reports an excellent series of specimens of all sizes collected in New Caledonia in the possession of M. Crosse, and a smaller lot of specimens of different sizes in the Stuttgart Natural History Museum and he considers all of them as belonging to this same species, and that the differences are only due to growth.

Meijere (*loc. cit.*), records that young specimens of this species in the Siboga Expedition Collection from Ambon and Makassar, show the typical form; they are reported to be broadly oval, the middle (median) ambulacra being pointed slightly forwards; the body (test) is low; those from Makassar are said to be specially low in front, so that in a lateral view they slope gradually from the hind end to the front end. The specimens from Ambon are reported to be nearly as high in front as the hind and (i.e., about 17 mm.). The spines on the outside are fairly long, and not enlarged or widened at the tips and therefore rather sharply pointed. On the contrary, those on the oral plastrons are flattened and distinctly widened at their ends. The hind ambulacra on this side of the body are thickly covered with fine, small spines. These spines are arched (curved or bent) at the ends and slightly toothed on one side.

On the other hand, specimens in the Siboga Collection from Station 193 and Station 225 (specimens which, unfortunately, have naked bodies) are said to be, on the whole higher—one specimen with a length of 32 mm., is reported to have a height of 22 mm.—but they are also slender. The apex is reported to be rounded more towards the front and the middle ambulacra from nearly a straight line or even inclined slightly backwards. The subanal fasciole lies directly on the truncated end of the body. The colour is dark brownish. The spines on the apical side in these specimens are reported to be crowded together, very little different from one another and not considerably widened at the ends; only the spines found near the petals are slightly longer. The spines on the oral plates have the same form and are only about 3 mm. in length. The miliary spines of the hind ambulacra of this side of the body differ from those of the above mentioned specimens; they are described as being definitely provided with clearly toothed grooves right up to the end.

In view of the presence of all these different characters, it is possible that it might be considered that such specimens belong to a different or distinct species. There is, however, no doubt that such specimens have been identified by notable authors as *Metalia sternalis*. In Meijere's opinion, they agree with the specimens from Kingmill Island, which Agassiz also has determined as distinct species—*Xanthobrissus garetti*.

The original diagnosis of the same, namely, "Anal system large, pointed at both extremities. Posterior ambulacra arched exteriorly; a few large tubercles near the apex of the rosette on both sides of the anterior ambulacra. Tubercles numerous, small; spines very slender, quite long"—agrees with the main points, only, in the Siboga Expedition specimens reported by Meijere, the hind (posterior) ambulacra are scarcely arched exteriorly, but nearly straight. As regards the "long" spines, the same author says later in his "Revision of the Echini" that the spines are short and agree with those of *Metalia sternalis*. At this point, Agassiz interprets his specimen of *Xanthobrissus garetti* as being a young specimen of this species in that it is a transitional stage of *Metalia sternalis*. Meijere's Siboga specimen agrees nearly completely in profile view with the very same illustration given by Agassiz; only, his (Agassiz's) specimens are slightly broader and the middle ambulacra point forwards a little more markedly.

Clark H.L. (*loc. cit.*), records an exceptionally large specimen of this species in the British Museum collection from Mauritius measuring 182 mm. long by 160 mm. wide and 110 mm. high. He also reports a very small specimen of this species from Gilbert Island measuring 30 x 28 x 20 mm. He further records the colour of a specimen of this species from Andaman Islands in which the test is orange-red, and many spines are white throughout, but many other spines are orange-red, tipped with white.

This species is widely distributed in the Indo-Pacific Region and has been specifically recorded from the following localities: Ambon, Makassar, Sandwich Islands, Society Islands, East Indian Islands, Australia, Red Sea, Mauritius, Amirantes, Andaman Islands, Singapore, North Eastern Australia, Pacific Ocean, Kingmill (= Gilbert) Islands, and also from Tuticorin on the East Coast of India.

Specimens in the collection.—One dry-preserved specimen exhibited in the Gallery. Locality: Tuticorin.

The test is moderately large, deep brownish more or less regularly and broadly ovoid, almost as long as broad, being equally broadly rounded at both the posterior and anterior margins, somewhat depressed, and with the anterior border broadly indented at the middle. The petaloid areas are deeply depressed and sunken in broad concavities. The test in the present specimen is completely denuded of its spines and hence the rows of broad, hexagonal plates forming the test and entering the interambulacral areas, and the numerous uniformly small, closely crowded tubercles, covering almost the entire surface of the test can be clearly seen. Only few of these tubercles in the interambulacral areas between the median anterior petal and the lateral petals are larger and more prominent. The anterior ambulacrum does not bear any poriferous zones.

Measurements :

Length of the test : 56 mm.

Maximum width of the test : 53 mm.

Height of the test : 28 mm.

Length of the posterior petal : 18 mm.

Length of the lateral petal : 18 mm.

CLASS ASTEROIDEA.

The Asteroidea are flattened, mostly pentagonal, Eleutherozoan Echinoderms of star-like form with normally five (sometimes more) long or short rays or arms radiating symmetrically from a central disc. The oral surface is held downward and the animal moves on the oral surface. Most Asteroids have a flexible body, but in some (e.g. *Astropecten*) the body and arms are almost rigid. Each of the arms contains gonads and a pair of digestive glands, with open ambulacral grooves confined to the oral surface and provided with two or four rows of podia which are locomotory. The radial water vascular vessels are located to the outer side of the ambulacral ossicles. The ambulacra extend from the peristome to the tips of the rays. The ambulacral pores are situated between the ambulacral plates. There is a well developed endoskeleton composed of separate calcareous pieces bound together by connective tissue and usually bearing externally projecting knobs, tubercles or spines.

The Asteroidea comprise the marine animals commonly known as starfish or, more correctly, sea stars. The general appearance of a sea star is quite different from that of the representatives of the other classes of Echinoderms. The body is strongly flattened in the oro-aboral axis and therefore presents a well defined and distinctly differentiated oral and aboral surfaces.

This Class includes five Orders of which two consist exclusively of extinct forms while the living members of the Class Asteroidea belong to one or other of the remaining three Orders, namely, the Phanerozonia, the Spinulosa and the Forcipulata. Species belonging to all these three Orders are represented in the Museum Collection.

In the Order Phanerozonia (e.g., *Stellaster*, *Anthenea*), the arms are bordered by two rows of conspicuous rectangular plates, an oral and an aboral row, the line of division between the two rows defining exactly the boundary of the two surfaces. In the other two Orders, *Spinulosa* and *Forcipulata*, conspicuous marginal plates are usually wanting and the oral and aboral surfaces often merge imperceptibly into each other.

ORDER PHANEROZONIA.

The arms are bordered laterally with two rows of large, rounded, squarish or rectangular, conspicuous marginal plates, an aboral supra-marginal row and an oral infra-marginal row. The rest of the body surface (apart from the ambulacral areas) in most Phanerozonia and especially in the Suborder Paxillosa is supported by closely set plates from which erect columns with expanded tops, covered with little tubercles or spinelets, arise. This entire individual skeletal piece, resembling a mushroom is known as the *Paxilla*. The marginal plates are usually covered with the same little tubercles or spinelets as are found on the tops of the paxillae; or these spinelets may be enlarged so as to form a row of marginal spines.

Pedicellariae, when present, are of the sessile or alveolar type. Papulae are limited to the aboral surface. The mouth frame is of the adambulacral type.

Only two Suborders of this Order are represented in the collection of this Museum, namely, Paxillosa and Valvata. In the former, the aboral surface is formed of paxillae and the podia are without suckers, while in the latter, the aboral surface is formed of plates ranging from paxillae to a flattened mosaic pattern and the podia are provided with suckers.

SUBORDER PAXILLOSA.

The aboral surface is formed of paxillae; the podia are without suckers and the ampullae are bifurcated.

Species belonging to two families of this Suborder are represented in the Museum collection, namely, Astropectinidae and Luididae.

In the Astropectinidae, the body is more regularly stellate and the arms proportionately shorter and broader at the base and the disc relatively larger. In the Luididae, on the other hand, the stiff, star-like appearance is lacking and the arms are long and flexible and the disk relatively small. Many species of this family have more than five arms, generally six to eleven arms.

Family ASTROPECTINIDAE.

The back is flattish, netted with numerous tubercles, crowned with radiating spines at the tip, called *paxilli*. This is a large family including numerous species. The body is typically stellate (star-shaped), and is provided with conspicuous marginal plates and respiratory grooves between the marginal plates. Super-ambulacral ossicles are present in the interior in the lateral angles of the arms. In most genera, the lateral margins of the arms are bordered by a fringe of pointed spines.

This family is represented in the Museum Collection by species belonging to two genera, namely, *Astropecten*, which is the main genus of the family, and *Persephonaster*, which is closely allied to the genus *Plutonaster*, and which was formerly included in a separate family, the Archasteridae. The genus *Astropecten* is characterized by elongated inframarginals which meet the adambulacrals to form the oral surface of the narrow rays. In *Persephonaster*, thick, block-like supra-marginal plates occur forming a massive border on the abactinal surface of the arm.

The genus *Astropecten*, which is much commoner and more widely distributed than *Persephonaster* in Indian waters, is represented in the Museum collection by five species while the genus *Persephonaster* is represented in the Museum collection by only a single species.

Genus *Astropecten* Link.

Members of this genus are flat, somewhat rigid, five pointed sea stars with a fringe of spines bordering the arms (hence the popular name "fringed starfishes" sometimes applied to the species of the genus), and with the elongated infra-marginals meeting the adambulacrals to form the oral surface of the narrow rays. The adambulacral spines are simple, linear, without any tesserae between the marginal tubercles near the mouth and angles of the arms.

Astropecten indicus Döderlein.

FIGURE 57.

Astropecten indicus, Döderlein, Echinodermen von Ceylon, Zool. Jahrb. Abth. fur Systematik, Band III, p. 828, pl. xxxi, fig. 2.

Astropecten Koehleri, de Loriol (P.), Notes pour servir a l'etude des Echinodermes, VII, Mem. Soc. Phys. et Hist. Nat. Geneve, XXXIII, p. 19, pl. 1, fig. 5.

Astropecten indicus, Koehler, "Shallow Water Asteroidea", Indian Museum, Calcutta, 1910, pp. 27 - 31, pl. iv, figs. 8 - 15.

Astropecten indicus, Döderlein, "Asteriden", Siboga-Expeditie, XLVa (=livr LXXXI), *Astropecten*, etc., 1917, pp. 53, and 146-147 pl. ziv, figs. 4-4a.

Astropecten indicus, Gravely, Bull. Madras Govt. Mus. (Natural History), I, No. 1, 1927, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", p. 168.

This species, *Astropecten indicus*, has been established by Döderlein, based on specimens in which R. (i.e., the radius, or length from the centre of the disc to the tip of the arm) varies from 19.5 mm. to 22.0 mm. But among the numerous specimens from the Indian Museum's Collection examined by Koehler, he found a certain number of specimens, the size of which surpassed those of the largest specimen studied by Döderlein. The dimensions of R reach about 40 mm. and, as in the specimen from Embouchure du Deir, and in several others, R varies between 30 and 38 mm. In the larger number of specimens examined by Koehler, the value of R is about 30 mm.

In the specimens on the basis of which Döderlein has established the species *Astropecten indicus*, the dorsal marginal plates are said to bear granules a little larger than the others representing the spines which exist in the other species. In a certain number of specimens of this species from the Indian Museum at Calcutta, examined by Koehler, particularly in those which were collected from the Madras area and in some others, the dorsal marginal plates are simply covered by granules and they do not present the slightest indication of spines; in certain other specimens, on the contrary, these plates seem to be armed with a spine, but there is a great deal of variation in respect of this character. In the specimens in which they are the last armed, the marginal plates carry in the terminal part of the arms, each a small spine, very short, rounded, and which sometimes does not exceed the size of a large granule; besides, the spine appears on the greater part of the length of the arms, except on the first five or six plates; it remains, in general, very short and cylindrical, with the extremity rounded, and it is always in the neighbourhood of the external margin of the plate. In other examples, the first marginal dorsal plates carry a spine, but this appears on their internal border and it is also noticed that the first, or the first two spines are always larger than the others. Following the first plates armed with a spine on their internal border, there are two or three which are unarmed, and then follow the plates which more or less in a constant number bear spines on their external border.

In some examples examined by Koehler, as those from de l'Embouchure du Deir, in which R = 40 mm., the internal spines occur on the first three or four plates, then, towards the fifth, the spines leave the internal border, advance towards the middle of the plate and on the sixth or seventh plate reach the external border in such a manner that there is no interruption between the internal series and the external series of spines. It might even happen that the sixth or seventh dorsal marginal plates bear two spines, one external and the other internal. In all these cases the spines assume the form of rounded granules or blunt cones, or, on the contrary, may be developed as small spines. Generally speaking, however, the internal spines of the first marginal plates are stronger than the others, conical and pointed. The size of the specimens does not appear to have any influence on the armature of the dorsal marginal plates.

The marginal spines are reported by Koehler to have been particularly well developed in a lot of six specimens of this species collected from the Coromandel Coast represented in the Indian Museum Collection. They are all smaller than the average and the value of R varies between 23 and 25 mm. In all of them, the dorsal marginal plates are said to bear a small, well developed and very distinct spine, conical and pointed, on the first plates, of which it occupies the internal border, with the extremity projecting over the succeeding plates; in these ones, the internal spine passes, as usual, to the extreme border on the fourth, fifth and sixth plates, but on the others, Koehler reports that, starting from the fourth or from the fifth plate, a second spine appears on the inside of the principal spine towards the internal border of the plate, without continuing the internal series

which has already disappeared. This supplementary spine does not occur on two or three plates only, but in the specimen which Koehler has depicted in Plate IV, fig. 10, in his Account of the Shallow Water Asteroidea of the Indian Museum (Koehler, *loc. cit.*), it is continued up to the twelfth plate. Based on all the other characters, these six specimens are absolutely identical to the other specimens of *Astropecten indicus* of the Indian Museum Collection examined by Koehler, which are of the same size. But on the other hand, the specimen depicted by him in plate IV, fig 10, is absolutely identical to a specimen in Koehler's personal collection and which belongs to a lot of *Astropecten* collected from Pondicherry, of which a specimen was formerly given by him to M. de Loriol who considered it as belonging to a new species and had described it under the name of *Astropecten Koehleri* (de Loriol, *loc. cit.*).

One other variation commonly noticeable in *Astropecten indicus* is in respect of the relative length of the arms. Normally the form is identical to that which Löderlein has indicated in his illustrations (*loc. cit.*). The arms are relatively wide, rather short, with the extremity more or less obtuse; the paxillar area is large and the dorsal marginal plates are themselves rather broad. However, the arms are sometimes more elongated and the paxillar area then become comparatively narrower.

Finally, the integument of the ventral surface of the ventral marginal plates present some variations. The covering consists essentially of scales or squamules amongst which are always found raised spines (at least at the commencement of the arm) which approach the distal border of the plate. These spines do not extend beyond the fourth or the fifth ventral marginal plate as in the specimen illustrated in Plate IV, fig. 11 of Koehler's Monograph (Koehler, *loc. cit.*); in others, they are, on the contrary, continued up to a certain length, and in the specimen illustrated in Plate IV, fig. 12 of Koehler's Monograph (Koehler, *loc. cit.*), these spines extend to an exceptionally great extent. The presence of these spines constitutes one of the diagnostic characters of the species *Astropecten indicus*. They are therefore of value in identification. On the external border, the ventral marginal plates carry at least three spines. The outward (external) one, much longer and stronger, is flattened with the point, however, slightly blunt; it is usually not very well developed.

The paxillae are frequently confluent and, in all cases, very small in the central region of the disk. Their size increases rapidly, and, at the base of the arms, the largest ones bear central granules, of which there are about 8 or 10 in the largest specimens, with a crown of a dozen or fifteen peripheral granules, a little more elongated. As the paxillae become smaller, their central granules also diminish in number correspondingly until finally in the smallest paxillae they are reduced to two or even a single one which is surrounded by a circle of more elongated granules.

The two adambulacral spines of the external row are very unequal and the distal spine is always remarkably well developed, being very much longer and thicker, relatively, than the proximal spine, which, by contrast, is extremely small; this arrangement constitutes an excellent diagnostic character for identification. Apart from these two spines, there are a few others, very much smaller, their number varying according to the size of the specimens.

Among the specimens of the collection examined by Koehler, there are a few which are reported by Koehler as approaching *Astropecten Koehleri* Loriol very closely, or even as being absolutely identical with the specimens he had collected from Pondicherry and of which one had served as the type for Loriol for the establishment of this species. These specimens, of which some are from the Orissa Coast and the others are from the Coromandel Coast, have the body a little thicker and their appearance is a little more robust than the others. However, after the comparisons that he has been able to make, Koehler is of opinion that there is no reason to retain *Astropecten Koehleri* as a distinct species and that this form constitutes at best only a variety of *Astropecten indicus*.

Specimens in the collection.—(1) One young specimen from Royapuram Bay, Chingleput District.

Measurements: $R = 20$ mm.
 $r = 6$ mm.

Width of the arm at base: 6 mm.

Colour: Dorsal surface: brownish grey; marginal plates: whitish; ventral surface: whitish; ambulacral grooves fairly wide, dark brownish.

(2) One large specimen from Kutikal, Gulf of Manaar: the arms are fairly broad and thick.

Measurements: $R = 40$ mm.
 $r = 16$ mm.

Width of the arm at base: 17 mm.

The first seven or eight dorsal marginal plates carry two spines each (blunt), and the remaining distal ones carry three spines each. The surface of the ventral marginal plates is covered by minute scales or squamules.

Colour: Dorsal surface: brownish grey; ventral surface: creamy white; ambulacral grooves: brown.

(3) Three young specimens from the Madras Coast:

Measurements: (of the largest of these three specimens):
 $R = 26$ mm.
 $r = 11$ mm.

Colour: Dorsal surface: pale greyish brown; ventral surface: whitish; ambulacral grooves: dirty brown.

(4) Five large specimens from Kilakarai, Ramanathapuram District: In almost all of them, the tips of some of the arms are incomplete.

Measurements: (of the largest specimen of this lot).
 $R = 52$ mm.
 $r = 15$ mm.

Width of the arm at base: 13 mm.

Colour: Dorsal surface: brownish grey; marginal plates: pale yellowish brown; ventral surface: creamy yellowish brown; ambulacral grooves: dark brownish.

(5) Two rather moderate-sized specimens from Krusadai Island, Gulf of Manaar (1925).

Measurements: (i) of the first specimen:
 $R = 28$ mm.
 $r = 12$ mm.

Width of the arm at base: 10 mm.

Colour: Dorsal surface: brownish grey; ventral surface: dirty whitish; ambulacral grooves: dark brownish.

(ii) The second specimen in this lot is also almost of the same size and colour.

NOTE.—Dr. Gravely (*loc. cit.*), has referred to one specimen from Kutikal and two from Krusadai Island in the Gulf of Manaar. These are presumably the specimens cited as Nos. 2 and 5 above, respectively. The arms are slender and bordered by a conspicuous row of plates with strong spines on their outer side. The disk is relatively small; these characters are typical of this species and are well seen in these specimens from Kutikal and Krusadai Island in the Gulf of Manaar.

they appear smaller. The paxillar area always appears rather extensive and wide throughout the length of the arms on account of the relatively slight development of the marginal plates on the dorsal surface.

The madreporic plate is relatively very small and its diameter is not greater than those of the neighbouring paxillae which more or less encroach on its margins. Its ridges are less numerous. In the small specimens, it is placed close to the margin and is separated from the dorsal marginal plates only by two rows of paxillae. In certain specimens it is separated by three rows, and in the largest specimens, it is separated by five rows.

The dorsal marginal plates, of average dimensions, are broader than long, and, at the commencement of the arm, they appear almost twice as broad as long when the animal is seen from the dorsal surface. The margin which they form is relatively narrow when compared to the paxillar area which is very large. They are very slightly overlapped by the ventral marginal plates below. In the largest specimen examined by Koehler (*loc. cit.*), he has reported that there are about forty-eight to forty-nine plates, and in the next largest specimen forty-six plates. In the largest specimen, the dorsal surfaces of the plates are also reported to be united to the lateral surface at a right angle, while in other specimens this union is observed to be marked by a rounded border and the lateral surface is only slightly elevated. The plates are covered by rounded granules, rather large, but scarcely projecting, approximating one another closely and forming a half dozen very irregular rows. On the adjacent margins, the granules become very small and at the same time a little elongated. In medium-sized specimens, towards the fifth or sixth marginal plate, there appears abruptly in the middle of the external margin, a small, conical spine, the tip of which is sometimes pointed and sometimes blunt. A similar spine occurs on each of the succeeding marginal plates up to the extremity of the arm, progressively drawing closer to the distal angle of the plates. In the proximal part of the arm, the first marginal plate carries always towards its internal margin a strong, conical spine, enlarged at the base, a little flattened, thicker and stronger than those mentioned above, and this spine is distinctly and widely separated from the external spines by four or five marginal plates.

The disposition of the spines is a little different in the largest specimen. In these specimens, the first two marginal plates on each side carry each one a large internal spine, the second a little smaller than the first, and the external spine usually makes its appearance on the third marginal plate. On one of the arms Koehler had further observed one very small spine on the internal border of the third dorsal marginal plate and the external spine makes its appearance only on the fourth. The series of spines is therefore quite uninterrupted in this arm. Generally, the spines in these large specimens are relatively stronger, longer and more pointed than in the others.

In two smaller specimens examined by Koehler, it is reported that the spines do not disappear on the dorsal marginal plates, but they are reduced to simple, small, conical granules which appear always towards the 5th or 6th plate and the first plate carries, as usual, an internal spine.

The apical plate is quadrangular, truncated, almost as wide as long; it bears a rather deep groove on the middle of its dorsal surface.

The latero-ventral plates are two in number in each inter-radius. They carry elongated and straight, cylindrical spines which mark the beginning of the arrangement of the pedicellariae.

The ventral marginal plates are very broad and short; they are covered by flattened and elongated squamules amongst which occur more spines which are inserted on their middle as well as on their distal border. In the large specimens, there is always found, on the distal margin of the plate, half a dozen elongated and cylindrical spines.

The external margin carries a large spine flattened and pointed, the length of which equals about twice the width of the plate. At the base of this plate appear two spines less developed than the large spine mentioned above, but yet longer than those of the ventral surface.

The ambulacral spines present at first an internal series of three spines on each plate; these spines are flattened, with the extremity rounded and the median spine is a little longer than the other two. Then follows a median row comprising two spines, rather thick and flattened. The distal spine is a little stronger and longer than the others, apart from which, however, there is no much difference between the two. Finally, outside this second row, there occur some cylindrical spines, much shorter than the preceding, but disposed more or less irregularly. They form sometimes a third row of three spines, behind which there are again two or three spines disposed without order. The first ambulacral plate on each side is elongated, along the external margin of the corresponding tooth and it carries two parallel rows of very regular, equal and cylindrical spines, each row being composed of up to a dozen spines. The second plate is also more elongated than the succeeding and the spines are again disposed sufficiently regularly. However, an internal row of three spines, a median row of two spines a little larger, and then a series of five or six pairs of smaller spines can be clearly distinguished.

The teeth present on their ventral surface a row of one dozen flattened, short, lamellar spines of which the last extends under the terminal spine. Outside this, there is yet another irregular row of half a dozen cylindrical and short spines. On their free margin in the oral region, the teeth carry about eight spines which progressively increase in size; the two last ones are very long and are directed horizontally towards the mouth.

Specimens in the collection.—All the specimens of this species represented in the Museum's collection are contained in its Reference Collection.

(1) One specimen.—Wet-preserved. Locality: Seven pagodas, Mahabali-puram, Chingleput District.

Measurements: $R = 33$ mm.

$r = 11$ mm.

Width of the arm at base: 10 mm.

Marginal plates: 28-29.

The paxillae are crowded and small in the centre of the dorsal surface, but become larger peripherally.

The colour of the dorsal area is brownish. The spines are rather small.

(2) One specimen: Wet-preserved. Locality: Ennur, Chingleput District.

Measurements: $R = 32$ mm.

$r = 12$ mm.

Width of the arm at base: 14 mm.

Marginal plates: 26.

The paxillae are small and closely crowded in the central area, but become larger and more widely spaced towards the periphery.

The colour of the dorsal area is lighter brown than in the preceding specimen. The marginal plates are whitish. The arms are comparatively shorter and broader at the base in this specimen than in the preceding one. There is a slight depression in the centre of the dorsal surface.

(3) Two smaller specimen: wet-preserved. Locality: Kilakari, Ramanathapuram District. These are young specimens.

(i) Larger of the two specimens:

Measurements: $R = 21$ mm.; $r = 7$ mm.

Width of the arm at base: 7 mm.

Colour: Dorsal surface: light brown; ventral surface: light creamy yellowish white; ambulacral grooves: dark brown.

(ii) Smaller of the two specimens:

Measurements: $R = 19$ mm. $r = 6$ mm.

Width of the arm at base: 6 mm.

The colour of the specimen is the same as that of the larger specimen from Kilakarai, Ramanathapuram District, mentioned above.

***Astropecten hemprichii* Muller and Troschel.**

FIGURE 59.

Astropecten hemprichii, Muller and Troschel, 1842, System der Asteriden, p. 71.

Astropecten articulatus, Michelin, 1845, Essai d'une Fauna de l'île Maurice, Mag. de Zool., 2nd Series, 7^e année, p. 24; (non *Asterias Articulatus* Say, 1825).

Astropecten mauritianus, Mobius, 1881, Beitr. Z. Meeresfauna d. Insel Mauritius, p. 50. (non *Astropecten mauritianus* Gray 1840).

Astropecten hemprichii, Loriol (P. de), Notes pour servir à l'étude des Echinodermes, VII, Mem. Soc. Phys. Hist. Nat. Genève, t. xxix, figs. 7 and 8.

Astropecten hemprichii, Sladen, Journ. Linn. Soc. London, (Zoology), XXI, 1880, p. 324.

The original locality of the type specimen of this species is Sir William James Island and it was collected on 7th December, 1881. The type specimen, preserved in the Berlin Museum was collected by Hemprich and Ehrenberg in the Red Sea. The form appears to be closely allied to *Astropecten scoparius*.

This species has been carefully figured and described by De Loriol on the basis of the material obtained from Mauritius (*loc. cit.*, De Loriol).

There are five arms. The ratio of the smaller radius to the larger radius is as 1:4 1/3. The podia in the ambulacral grooves are arranged in many rows. On each plate is found a wedge-shaped protuberance on the tip of which is a papilla. The spines on the ventral plates are superficially soft and almost hair-like. Only in the vicinity of the marginal spines there are very fine spines which are half as long as the marginal spines. The dorsal marginal plates, numbering thirty-three on each arm are higher than broad. The spines on these plates are long, conical and pointed, and the ones that are found in the angles are vertical and form a distinct row at the margin. On the second and often on the third plate from the bases of the arms, there are no spines at all. A second outer row of spines is seldom to be seen. The granules on the dorsal marginal plates are conical. The dorsal areas between the dorsal marginal plates are broad and extensive.

This species attains a large size, sometimes reaching an overall diameter of one foot.

The type locality of this species is Red Sea.

series just mentioned, and, standing on the same level, forms together with it, the horizontal fan of mouth spines which proceed from each mouth angle and cover the mouth. The adambulacral plate adjoining the mouth plates is much broader and shorter than the others, and bears a lineal series of eight or nine short papilliform spinelets on each side, the two series being apposable.

The madreporiform body is entirely hidden by paxillae.

The colour of the specimens in spirit is normally ashy grey.

Fisher (*loc. cit.*), reporting on the specimens of this species from the Philippine Seas states that *Astropecten monacanthus* is readily recognized by its fairly large paxillae, unarmed granulate supermarginals (the granules flattened and sometimes squamiform), the close armature of rounded, imbricating inferomarginal squamules, the single flattened lateral spine, with a small companion just below it, and the highly characteristic adambulacral armature. The latter consists of three flattened furrow spines, truncate or round tipped, the median with edge towards the furrow. These are succeeded by two narrow, flattened subambulacral spines, so placed as to appear to form an arc of five with the furrow spines. They are shorter than the lateral furrow spines, usually tapering and bluntly pointed. Commonly only the aboral one is present. Behind these are two very broadly spatulate, round tipped or truncate spines, about as long as the lateral marginal spines, the aboral slightly the larger. Sometimes the aboral member of the first actinal series moves back a little, broadens and stands in line with the two spatulate spines, making a series of three; or, it may stand out of line in which case it forms a curved series with the two spatulate spines.

The first two inferomarginals may have several squamules enlarged, and forming a transverse series of two or three accessory flat, leaf-like spinules in line with the accessory marginal spinule.

The type locality of this species is east of Panay, Philippine Islands, in mud, at a depth of 20 fathoms (Challenger Expedition).

The distribution of this species ranges over Philippine Islands, Andaman Islands, east Coast of India and the Red Sea.

Specimens in the collection.—Two specimens, wet-preserved, in the Reference Collection. Locality: North-East of Devi River, Orissa Coast, 9 fathoms, Marine Survey.

Of the two specimens, one is entire; the other is slightly broken at the tip of three of its rays.

(i) Specimen with broken tips of arms:

Measurements: $R = 47$ mm.;
 $r = 15$ mm.

Supero-marginal plates 27 in number.

Diameter of the disk: 24 mm.

The spines of the infero-marginal plates are white, horizontally directed outwards from the margins of the rays and are tapering to a very fine tip and are very slightly curved. The ambulacral grooves are darker brown.

(ii) Entire specimen:

Measurements: $R = 45$ mm.;
 $r = 14$ mm.

Supero-marginal plates 27 in number.

Diameter of the disc: 24 mm.

The colour is the same as that of the above-mentioned specimen.

Astropection zebra Sladen.

FIGURES 61 AND 62.

Astropection zebra, Sladen, Journ. Linn. Soc. London, Zoology, XVII, 1883, p. 261.

Astropection zebra, Sladen, Asteroidea, Challenger Reports, (Zoology, XXX, 1889, p. 212; pl. xxxvi, figs. 3 and 4; pl. xxxix, figs. 7 and 9.

The rays are five in number. [The measurements of a normal adult specimen are as follows: $R = 34$ mm.; $r = 9$ mm.; $R = 3.7 r$. The breadth of a ray at the base is about 9 mm.

The rays are rather narrow, and although tapering gradually from the base to the extremity, the tip is comparatively obtuse. The interbranchial arcs are distinctly rounded.

The paxillae of the abactinal area are large, having one to four, or even more, central spiniform granules on the tabulum, surrounded by eight to twelve short spinelets in a circle on the periphery. A slight prominence is present in the disc of some specimens, but scarcely sufficient to produce a conical peak. In some specimens a slight invagination occurs in the centre of the prominence.

The supero-marginal plates, which are twenty-five in number from the median inter-radial line to the extremity, are higher than broad and have the appearance of forming a rounded, sloping level to the ray, especially in the interbranchial arc. The plates are uniformly covered with papilliform granules, and bear no spines or tubercles whatever, excepting the innermost four plates on each side of the median interradial line. These four or five plates are armed with a short, conical and slightly compressed spinelet, the innermost being the longest and the others decreasing in size as they proceed outward.

The infero-marginal plates are much broader than high, and do not extend beyond the superior series, although in large specimens there is a tendency for the plates to appear to do so in consequence of the presence of a slight prominence on the plate on which the lateral spine is articulated. There is one lateral spine of moderate length, which tapers throughout, and is sharply pointed, cylindrical and very slightly flattened; this is accompanied by a second spine, about two-thirds the length of the lateral spine, placed immediately behind, and close to the aboral side of the plate. Two or three small, compressed spinelets are situated in line on the aboral side of the plate, that near the inner extremity adjacent to the adambulacral plates being often slightly larger. No other spines are present on the infero-marginal plates, which are covered with moderately well spaced squamules.

The armature of the adambulacral plates is arranged in three series on the inner part of the ray, but becomes reduced to two on the outer portion. The inner or furrow series consists of three spinelets, which are rather short—the middle one being delicate and clavate at the extremity and the adjacent lateral ones rather shorter, flat and obtuse. The second series consists of two or three spinelets shorter than the inner series and more or less flattened and truncate. When a third spinelet is present, it is very frequently placed somewhat behind other two, opposite their interspace, and might almost be ranked with the third series, which latter may consist of only two or three small, cilia-like spines, or of four, flat, modified spines, forming a well developed pedicellaria. These organs are irregular in their occurrence, and are only present in the inner half of the ray; on the outer part of the ray, the third series of spines of the adambulacral armature is apparently wanting altogether. The pedicellariae are large and conspicuous and four or five are present along each side of a furrow, usually on alternate plates; all of them are uniform, and with four valves, regularly apposed two and two, the spinelets which form the valves being more or less flattened and arched, and terminating in an abruptly pointed or lanceolate extremity.

The actinal interradial areas are large, the intermediate plates extending much more than half way along the ray (i.e., to about the eighteenth infero-marginal; in the interradial areas each plate carries a pedicellaria-like clump of from six to eight truncate or clavate, grooved spinelets, and along the rays the intercalated plates have usually two short longitudinal series of similar spinelets — about four in each series).

The madreporiform plate is small and inconspicuous or concealed, situated about midway between the centre and the margin of the disk.

The ambulacral groove is very broad and open; the podia are large and conical.

The colour of the specimens in the fresh state is described as that of "crushed strawberry" with sometimes a golden suffusion; the marginal plates are pink and the podia blood red.

This species is a deep sea form and has been recorded from the Laccadive Sea and Gulf of Manaar from depths of 738 to 902 fathoms, in green mud.

In a very young specimen of this species, a granular epiproctal tube was observed by Wood-Mason and Alcock.

Specimens in the collection: There is one specimen in the Reference Collection, preserved in spirit, in a rather bad condition. The locality is noted as "off Cape Comorin". The broken condition of the specimen renders it difficult to be measured accurately. Subsequently, the specimen has been partly restored and repaired and preserved and mounted as a dry specimen.

Family LUIDIIDAE.

The rays are without any large tubercles on the margin. The arms are long and flexible and the disc is relatively small. The species included in this family generally attain a large size. Many of the species are five-rayed, but nearly half the number of species are multi-rayed, with six to eleven arms. This family comprises a single genus, *Luidia* Forbes.

Genus *Luidia* Forbes.

The margins of the five flat rays are erect. The dorsal surface is crowded with regular paxillae. The paxillae of the aboral surface of the disk and of the median aboral area of the arms are small and irregularly arranged, but towards the sides of the arms they become larger, squarish or rectangular, and disposed in definite rows and producing a tessellated appearance. The supra-marginals are reduced so as to appear to be identical with the adjacent papillae, while the infra-marginals are much elongated transversely and cover the greater part of the oral surface of the arms. The crowns of the paxillae consist of spinelets and the infra-marginals are covered with similar but larger spinelets. Pedicellariae are frequently present and are usually of the two-jawed type, but the bivalved and three-jawed types also occur. The papulae are branched. An anus is wanting. Species of this genus occur mostly in the tropical and subtropical waters.

This well known and sharply defined genus constitutes a very distinct type, the characters of which are remarkably constant, and subject to comparatively very little modification, as exemplified by the range of species at present known.

Sladen has placed this genus in a distinct subfamily by itself. Two points in the morphological structure of *Luidia* seem to justify this: the first is the correspondence of the infero-marginal and adambulacral plates and the second, the presence of a small

intermediate plate between each infero-marginal and adambulacral plate. The correspondence of the infero-marginal and the adambulacral plates has already been noticed by Alex Agassiz and Viguiier. But the intermediate plate, in spite of its taxonomic importance, had strangely enough been overlooked by the previous workers; in fact, the record of its presence is directly at variance with the statements of the other writers on this group. Thus Viguiier, who had made a careful study of the details of the Asterid skeleton, states that in *Luidia*, the marginal and adambulacral plates alone constitute the actinal skeleton of the rays, and that it is only in the interradial angles that the intermediate plates—smaller and less numerous than in *Astropecten*—are intercalated between the two series. The same opinion is held by Perrier, who, in his recent work on the Asteroidea of the "Blake" Expedition, regards the contiguity of the marginal and adambulacral plates as a character diagnostic of the family Astropectinidae (as constituted formerly), the genus *Luidia* being included in this category.

In the face of these statements, Sladen states that he should have hesitated in according a special significance to the intermediate plate, if his observations had been limited to a single species, but he reports that he had detected the presence of the intermediate plate in every species he had examined critically (although it might be small and more or less aborted in some cases; but it is present in all).

In the Indian Ocean, three species of *Luidia* have been recorded between the parallels of 30° N and 10° S., namely, *Luidia savignyi*, *L. maculata* and *L. hardwickii*.

Of these, *Luidia savignyi* is reported to be more common in the Red Sea and off the Coast of Africa.

Luidia maculata occurs in the Indian Ocean from the Coast of Africa in the West and extends to Java in the Eastern Archipelago and thence to the Pacific northward to Japan.

Luidia hardwickii is reported to occur in the Indian Ocean, but the exact locality is unknown.

Of the above three species only *Luidia maculata* and *Luidia savignyi* are represented in the Museum collection.

***Luidia maculata* (Muller and Troschel).**

FIGURE 64.

- Luidia maculata*, Muller and Troschel, 1842, System der Asteriden, p. 77.
Luidia maculata, Perrier, Revision de la Collection de Stellerides du Museum d'histoire naturelle de Paris, 1875, p. 338.
Luidia maculata, Sladen, Journ. Linn. Society, London, (Zoology), XXI, 1889, p. 327.
Luidia, maculata, Koehler, Catalog raisonne des Echinodermes recueillis par M. Korotnev, aux iles de la Sonde, Mem. Soc. Zool. France, 1895, p. 387.
Luidia maculata, Bedford, "On Echinoderms from Singapore and Malacca", Proc. Zool. Soc. London, 1900, p. 293.
Luidia maculata, Koehler, R., "Shallow Water Asteroidea", Indian Museum, Calcutta, 1910, p. 70.
Luidia maculata, Koehler, Asteries et Ophiures des iles Aru et Kei, Abhandl. Senckenberg. Naturf. Gesell., XXXIII, 1910, p. 267.
Luidia maculata, Fisher, "Starfishes of the Philippine Seas", Bull. United States National Museum, 100, Vol. 3, 1919, p. 168.

The arms are normally seven in number, and the specimens generally attain a large size. The arms in normal adult specimens attain a length of over 35 centimetres and a maximum width of 38 mm. at the base.

The species exhibits the typical characters of the genus enumerated above under the description of the genus *Luidia*.

Muller and Troschel (*loc. cit.*), in his original description of this species mentions that the arms are seven to nine in number. The back of the arms and the disc are very slightly raised (arched). The arms are eight times as long as broad. The furrow-papillae are sword-shaped and curved inwards; beyond a small blank space, three or four more spines are present. These are not so flat and are slightly curved. Generally, between these are found long, pincer-like pedicellariae which are three-cornered. The longest are half as long as the spines and are three to four times as long as broad. Then the ventral plates follow—in the form of a furrow. These are covered with spines, among which two to three slightly flattened, lancet-shaped spines appear. These lancet-shaped spines are found in two to three longitudinal rows on the arms. The innermost appear to be the longest. The paxillae of the dorsal surface have a completely four-cornered tip and are found in four regular longitudinal rows on the sides of the back. In the middle of the back these are smaller and are not arranged so regularly, so that it is difficult to differentiate the rows. The bristles on the paxillae are thicker and more granular in the middle of the paxillae, and truncated; at the margin they become thinner.

Colour: The entire surface of the specimen in the dry state, is covered with large grey spots which alternate with lighter coloured patches.

The type locality of this species is Japan, and the type specimen is in the collection of the Museum of Leyden.

Fisher (*loc. cit.*), reporting on the specimens of this species collected from the Philippine Seas, reports considerable variation in the size and shape of the paxillae in specimens collected from different localities.

The paxillae form five or six regular series in either side of the ray, but present a more open appearance due to the fewer number of spinelets and to the rounded corners of the crowns. A large paxilla at the base of the ray gives a circular or broadly elliptical contour to the strongly convex crown, which consists of about twelve to eighteen unequal, blunt, peripheral spinelets and 7 to 12 shorter, stouter, subtruncate, spaced divergent central spinelets. The stoutest spinelet stands in the centre, surrounded by a circle of 6, these in turn being surrounded by a partial circle of more slender spinelets intermediate in thickness between the central and the outermost. A considerable number of the supero-marginal paxillae, as well as a number in the next series adjacent, have one or two pedicellariae with two tapering jaws varying in length from somewhat longer to somewhat shorter than the spinelets.

The adambulacral armature consists of a curved, strongly compressed furrow spine followed by a much longer, tapering, slightly compressed spine. This, in turn, is followed by two (sometimes three) large pedicellariae with three long, slender jaws, more than one half, sometimes two-thirds the length of the subambulacral spine. The outer pedicellaria is situated, as a rule, upon an actinal intermediate plate, of which a single series occurs between the inferomarginal and the adambulacral plates. Occasionally, at the base of the ray, there are three adambulacral spines, the outermost much smaller than the principal spine. In addition, there are several small spinelets along the transverse margins of the plate. The number of adambulacral spines is variable.

The number of infero-marginal spines is proximally four (or sometimes three) the two innermost decreasing in size along the ray. The innermost spine is reduced to an inconspicuous spinule very soon, while the next persists for a variable distance, there

being usually on the outer half only two prominent spines, the two outer ones of the proximal half. Between these two there are often one or two pedicellariae with two or three jaws similar in form to those of the adambulacral plates, but only about two-thirds as long, and a little stouter.

Koehler (*loc. cit.*), records a very young specimen of this species from the Andaman Islands in which $R=10$ mm. It is reported that this young specimen already presents some spots on the dorsal surface of the arms.

Bedford (*loc. cit.*), records a single, large, 7-armed specimen of this species from between tide marks in Singapore, and Sladen (*loc. cit.*), has recorded a single young specimen in the sub-littoral zone from King Island in the Mergui Archipelago (native name : Padaw) on 24th January, 1882. This young specimen is said to have nine arms and its major radial dimension (R) is said to be 65 mm.

This species is a common member of the genus *Luidia* and is widely distributed in the Indo-Pacific Region. In the Indian Ocean it has been recorded from the Coast of Africa in the West to Java in the Eastern Archipelago, and thence to the Pacific, northward to South Japan. Bedford (*loc. cit.*), records that its distribution extends from Mozambique to Macclesfield Bank and northwards to South Japan.

Koehler (*loc. cit.*), records a very large specimen of this species from Baie de Balasore.

Fisher (*loc. cit.*), records the full range of distribution of this species as follows :—

Japan : Macclesfield Bank; Philippine Islands; Singapore; Malacca; Mergui Archipelago; Andaman Islands; India (Coromandel, Tuticorin, Madras, Bay of Balasore, Ceylon); Mozambique; Java Sea; Aru Islands; Torres Straits.

Specimens in the collection :—One large, dry-preserved specimen from Madras, exhibited in the Gallery.

Measurements :

R = 174 mm. (longest arm).

r = 23 mm.

R = 103 mm (shortest arm).

Overall tip to tip diameter : 320 mm.

The specimen is seven-armed. The arms are rather narrow, sharply demarcated from the disk, somewhat flattened and sub-cylindrical, tapering towards the tip. The tips of the arms are somewhat pointed. The aboral surfaces of the arms and disk are closely crowded with paxillae. The aboral surface is blackish grey, while the oral surface is pale creamy-white. The short closely crowded spines are conspicuous on the oral side of the arms marginally. The arms are unequal in length.

Luidia savignyi (Audouin).

FIGURE 65.

Luidia savignyi, Gray, Annals and Magazine of Natural History, VI, 1840, p. 183.

Luidia savignyi, Lorient, de P., Catalogue des Echinodermes recueillies à l'île Maurice par M.V. de Robillard, II, Mem. Soc. Phys. et. Hist. Nat. Geneve, XXIX, 1885, p. 72 (pars).

Luidia savignyi, Sladen, "On the Asteroidea of the Mergui Archipelago", Journ. Linn. Soc., London, XXI, 1889, pp. 246 and 742.

- Luidia savignyi*, Audouin, Description de l' Egypte Echinodermes, 1809, p. 209 pl. 3.
- Luidia savignyi*, Muller and Troschel, System der Asteriden, 1842, p. 77.
- Luidia savignyi*, Perrier, Revision de la collection de Stellerides du Museum d'histoire naturelle de Paris, 1875, p. 340.
- Luidia savignyi*, Bell, F.J., "Note on a remarkable large specimen of *Luidia* from the Island of Mauritius, Annals and Magazine of Natural History (6) Vol. III, 1889, p. 422.
- Luidia savignyi*, Ludwig (HO.), Echinodermen des Sansibargebietes Abth. Senckenb., Gesells. Bd. XXI, 1899, p. 539.
- Luidia savignyi*, Bell, J.F., "Report on a Collection of Echinoderms from the neighbourhood of Zanzibar," Annals and Magazine of Natural History (7), Vol. XII, 903, p. 1244.
- Luidia savignyi*, Bell, F.J., 'Report on the Echinoderma (other than Holothurians), collected by Mr. J. Stanley Gardiner in the Western part of the Indian Ocean', Trans. Linn. Soc. London, XIII, pt. 1, 1909, p. 19.
- Luidia savignyi*, Koehler, R., Shallow Water Asterdidea collected by the Royal Indian Marine Survey Ship, "Investigator", Indian Museum, Calcutta, 1910, p. 10; pl. i, fig. 5; pl. 6, fig. 3.
- Luidia savignyi*, Fisher, "Starfishes of the Phillipine Seas", Bull. United States National Museum, 100, Vol. 3, 1919, p. 170.

The arms are seven in number. In a typical adult specimen from the Andamans examined by Koehler in the Indian Museum Collection, the measurements are cited as follows :—

R = 60 mm.

r = 10 mm.

The spines which carry the majority of the lateral paxillae are very well developed, strong, conical and thick. The central region of the disk is occupied by the confluent paxillae and the limits of these show themselves only very little at the base of the arms. On the arms, these paxillae, large and of square shape, are disposed in rows, rather regular longitudinal and transverse rows. Each one of these bears some central granules, about 4 to 8 in number, and smaller peripheral granules. In the second (distal) half of the arm, the paxillae of the median line are sometimes confluent or irregular, and they do not always conform to the regular alignments which are noticed in the other regions. The two first external rows of paxillae do not present any particular character, but, on the subsequent ones, it rather frequently happens that one of the granules is developed into a very large, conical, pointed spine, thick at the base, and attaining a height 1.6 to 1.7 mm. These spines never appear on the median paxillae of the arms, but are restricted to the lateral paxillae which are contiguous with the two first external rows. They do not occur on the disk. In certain part of the arms, these spines form two sufficiently regular rows on each side.

The ventral marginal plates bear, towards their external border, three large principal spines. The two first, which are inserted on the ventral surface are subequal and the third, which arises from the same border of the plate, is longer. It is the marginal spine which is visible when viewing the specimen from the dorsal surface. All these spines are conical, with the extremity pointed. Sometimes, on the first row, a shorter spine is present on the inside of the first. Numerous spines, much smaller, accompany the preceding spines.

The adambulacral plates present at first a rather small internal spine, flattened and recurved; outside this, there is a second spine very well developed, strong, cylindrical and bluntly pointed. It is the principal adambulacral spine which one finds throughout the length of the arm and which strikes the view when one examines the ventral surface of the Starfish. On the outside, one observes a third spine, analogous to the preceding, but shorter and smaller. This spine is well developed only at the commencement of the arm and it rapidly becomes much smaller. In the place of this single spine, sometimes two are found.

There are three adambulacral spines and the spines of the ventral marginal plates are more numerous.

The pedicellariae are not very abundant, but they are also not scarce, and are not present on all the plates. They are inserted between the adambulacral spines and the spines of the ventral marginal plates, immediately against the external adambulacral spine. Almost all the pedicellariae are with three branches; they are large, and rather short. Koehler, however, records that a few pedicellariae in the specimen examined by him had only two branches.

The general colour of the specimens of this species is greyish. The dorsal surface bears irregular dark spots or blotches, much larger in the distal part of the arms.

Muller and Troschel (*loc. cit.*), describing this species mentions that the relations of the disc radius to the arm radius is 1:9, whereas in the specimen in the Museum collection, it is about 1:7. This ratio is, therefore, subject to variation within a limited range. Generally towards the inner side of the furrow is found a row of crooked or curved papillae, one on each plate. On the outer side of this row is another row of longer spines and similarly one on each plate. These are exactly like the spines of the oral side. On the ventral plates (up to the margin) are found big spines standing one behind the other. Besides, the oral plates are covered with small spines. There are about 140 oral plates on each arm. The paxillae of the back are made up of a stalk the end of which is surrounded by a crown of small extensions. Generally, in the middle of this crown, these processes are extended here and there in the form of a spine. The arrangement of the rows of paxillae follows the marginal line of the arms. The madreporic plate is very close to the margin. Pincer-like pedicellariae are found in the furrows.

According to Muller and Troschel, the colour of the specimens of this species collected from the Mediterranean and English Coasts is dark red above and straw-coloured on the under side. Sometimes the colour is reported to be orange. This species is said to attain a size of $1\frac{1}{2}$ to 2 feet in total diameter (from the tip of one arm to the tip of the arm on the other side directly opposite).

The place of collection of the specimens examined by Muller and Troschel, which are in the Anatomical and Zoological Museum in Berlin, are stated as the Mediterranean and English Coasts.

Fisher (*loc. cit.*), doubtfully refers to this species a small, seven-rayed specimen collected from the Philippine Seas. The measurements are cited as $R = 27$ mm., and $r = 5$ mm. The adambulacral spines are reported to be three, or sometimes four, there being a spine out of line (adorally) between the second and third spines. The abactinal spines are described as being very short.

The type locality of this species is Red Sea.

The distribution of this species ranges over the Red Sea, East Coast of Africa, Mauritius, Andaman Islands, Sulu Archipelago and the Philippine Islands.

Specimens in the collection.—A single spirit-preserved specimen in the Reference collection of the Museum, in all probability, belongs to this species.

Locality: Wadge Bank, 20 fathoms (dredged), 1928.

Measurements:

R = 94 mm.

r = 13 mm.

Diameter of the disk: 20 mm.

Colour: Greyish above, with irregular, broad, dark, band-like markings on the arms and dark blotches on the disk. The under side is creamy white, and the ambulacral grooves dark brownish. It has seven arms, of which three are badly mutilated and very incomplete. The arms are curled upwards at their tips in this specimen. The disc is comparatively small, and the arms are sharply demarcated off from the disk.

The specimen was originally unidentified and labelled only as *Luidia* sp. But from a study of its characters and their comparison with descriptions of the species *Luidia savignyi*, it appears quite probable that it belongs to the species *Luidia savignyi*, and hence it has been tentatively identified as such.

SUBORDER VALVATA

The Suborder Valvata includes all the remaining families of the Order Phanerozonia which have ordinary suckered podia. The aboral surface is formed of plates varying from paxillae to a flattened mosaic arrangement. The podia are provided with well developed suckers.

Three families of this Suborder are represented in the Museum's Collection, namely:

- (i) Goniasteridae
- (ii) Oreasteridae (= Pentacerotidae), and
- (iii) Linckiidae.

These families are also the common ones represented in the South Indian Coastal waters, under this Suborder. They may be distinguished as follows:—

- (1) Form of body stellate with disk and the base of the arms very broad, the arms almost merging with the disk. The arms are bordered by thick and massive marginal plates: Goniasteridae.
- (2) Sea stars of moderate to large size with short, broadly based arms (sometimes with almost no definite arms, the arms being represented only by angular points of the disk); skeleton reticulate, enclosing papular areas in its meshes. Tubercles are typically borne on the nodes of the net work; marginal plates on the arms large, but often concealed from surface view: Oreasteridae.
- (3) Disk small; arms long, flexible and cylindrical; marginal plates reduced and inconspicuous; surface often smooth, but sometimes tending to be slightly warty or granular: Linckiidae.

FAMILY CONIASTERIDAE.

This is the largest family included in the Suborder Valvata and comprises about fifty genera. It includes some of the most beautiful and brilliantly coloured species of sea stars. The family Goniasteridae includes sea stars of stellate form with broad disk and broadly based arms bordered by thick and massive marginal plates. The

general skeleton is composed of paxillae or more often of simple plate-like ossicles of varied form and usually the skeletal ossicles are covered over with a smooth or granular membrane.

Formerly, this family was described by the earlier writers under the name *Pentagonasteridae*; thus species of *Goniasteridae* (such as species of *Stellaster*, *Anthenea*, etc.), were included in the family *Pentagonasteridae* in the earlier monographs such as Gray's Synopsis of Starfish in the Collection of the British Museum (1866).

Three genera of this family, namely, *Anthenea*, *Stellaster*, and *Goniodiscus* are represented in the Museum collection, the first by three species, the second by two and the last one by one species.

These three genera may be distinguished as follows:—

- | | |
|---|---------------------|
| 1. Body depressed and covered with large flat, regular, six-rayed plates; the lower row of marginal plates (tesserae) with a series of compressed, mobile spines: ... | <i>Stellaster.</i> |
| 2. Body more robust and elevated, chaffy, with immersed, elongated, tubercle-bearing ossicles or plates. Both surfaces with large, scattered, two-lipped pores: ... | <i>Anthenea.</i> |
| 3. Very similar to <i>Anthenea</i> in shape and general appearance, but the two-lipped pores are much smaller, those on the dorsal surface being minute; both surfaces more often covered with small roundish granules: ... | <i>Goniodiscus.</i> |

Genus *Anthenea* Gray.

The body is five-rayed, chaffy, with immersed, elongated, tubercle-bearing ossicula; margin with regular rows of large tesserae; both surfaces (especially the under surface) bear scattered, large, two-lipped pores.

Three species of *Anthenea*, namely, *Anthenea regalis*, *A. pentagonula* and *A. rudis* are represented in the Museum collection. They may be distinguished as follows:—

- | | |
|--|-----------------------|
| 1. Body in the form of a pentagonal disc; back obscurely netted. with scattered truncated tubercles in diverging lines. Arms broad, half the width of the body: ... | <i>A. pentagonula</i> |
| —Back not as above; arms relatively longer and broader at the base and more or less merged with the disk ... | 2. |
| 2. Body attaining only a small to moderate size. The disk and arms are not very thick. The sides are deeply excavated in such a manner that the arms are distinct and even relatively long. Extremity of the arms rounded: ... | <i>A. rudis.</i> |
| —Body attaining a much larger size. The disk is large and the arms relatively broad and short and bluntly pointed, being more or less merged in the disk. The disk and arms are thick: ... | <i>A. regalis.</i> |

Anthenea regalis Koehler.

FIGURE 66.

Anthenea regalis, Koehler, R., "Shallow Water Asteroidea, collected by the Royal Indian Marine Survey Ship, 'Investigator' " Indian Museum, Calcutta, 1910, pp. 82—86; pl. ix. figs. 1—2.

Anthenea regalis, Gravely, "Shells and Other Animal Remains of the Madras Beach", Bull. Madras Government Museum (Natural History), V, No. 1, 1941, pp. 86 and 105.

Dr. Gravely (*loc. cit.*), has recorded this species from the Madras Beach, but a specimen of it from Kilakarai, Ramanathapuram District, is also represented in the collection. The disc is large, and the arms are relatively broad, short and bluntly pointed, being more or less merged in the disk. The arms are bordered by comparatively large plates as in *Astropecten*, but there is an extensive area between these plates and the five ambulacral grooves for the podia extending from the mouth to the tips of the arms on the under side, which is filled with more or less oval plates, each with a broad, slit-like cavity in the middle.

Koehler (*loc. cit.*) describes this as a new species and reports the type locality of this species as the Coast of Ganjam, Orissa. He records four specimens from this locality at a depth of 24 to 30 fathoms, represented in the Indian Museum Collection, one of which is reported to be a dried specimen.

In the largest specimen reported by Koehler, which is preserved in alcohol, and which is a little longer than the dried specimen, the measurements are reported as follows: $R = 110$ to 115 mm., and $r = 60$ mm.

The body is in the form of a star, and the sides are strongly excavated. The arms are quite distinct, although very large at the base and merged at the base with the disk. They rapidly diminish in width up to the extremity which is narrow, but not pointed. The disk and the arms are thick; the dorsal surface is slightly convex and the ventral surface is flat. The marginal plates form a wide border, and the dorsal plates are slightly overlapped below by the ventral plates. The margins of the body are thinned out to the end of the interbranchial arches where the dorsal and ventral marginal plates are found, while they become progressively thick, up to the extremity of the arms as a result of the development in height of the plates and principally of the dorsal marginal plates. The arms are turned up towards the dorsal surface at their extremity.

The contours of the dorsal plates and of the ossicles which surround them are badly defined. Each plate carries in general, a large tubercle, cylindrical and short and not narrowed at the extremity which is truncated, and terminates itself in a slightly convex and smooth surface. The largest tubercles do not exceed 2 mm. in diameter and the majority are only 1.5 mm. in width; their height varies between 1.5 mm. and 2 mm. The tubercles are relatively fewer in number and they are separated from one another by intervals of about 3 mm. towards the periphery of the disk and on the arms, but they are less close-set in the central region of the disk. These last form a circle of about 4 cms. diameter in which the tubercles are very irregularly disposed. These form, peripherally, quite regular longitudinal rows which are continued on the arms and which appear to be variable in number according to the individual specimens.

In the dried specimen examined by Koehler, the rows are reported to be more numerous; in that specimen he reports that at least two and sometimes three rows can be distinguished on each side of the carinal line while in the larger specimen preserved in alcohol and reported by Koehler, only a single distinct lateral row is said to be present, outside which begins a second row.

In this larger, wet-preserved specimen, Koehler reports that the carinal row starts, at the level of about 2 centimeters from the centre, with a tubercle, a little larger, but shorter than the adjoining ones, and from there the tubercles are continued. There are about seventeen or eighteen of these tubercles, diminishing gradually in size distally, especially in the second half of the arm, but they do not reach quite up to the extremity, while the lateral tubercles are continued a little further. Beyond the tubercles of the second row, a few other tubercles occur, forming transverse rows which extent up to the

dorsal marginal plates of each side of the inter-radial lines. The five inter-radial spaces are in the form of broad bands which always remain naked (i.e., devoid of tubercles). These spaces are about 12 to 15 mm. in width. Koehler reports that in the dry-preserved specimen examined by him, these bands are somewhat depressed and their width does not exceed 10 mm. Towards the border of the disk and the arms, some conical tubercles are reported to occur in that specimen, presenting a rounded point instead of a truncated extremity.

In the interspaces between the spines, there are a few, scanty, small, rounded granules, and a few larger, valvular pedicellariae, but these never attain a large size and do not exceed 1.2 to 1.5 mm. in length; besides, they are very much less abundant. The pores are numerous, very fine and isolated.

The anus, which is central, is surrounded by a few small spines, set obliquely. The madreporic plate is very distinct and forms a slight projection; it may be oval or rectangular.

The dorsal marginal plates are about fourteen in number. The last plate is narrow and is contiguous with its counterpart on the median line and it surrounds a part of the periphery of the apical plate which is small and only slightly prominent. This apical plate is situated entirely on the dorsal surface by reason of the shape of the extremity of the arm which is always more or less turned upwards in all the specimens of this species. At the bottom of the inter-radial arches, the dorsal surface of the marginal plates is directed obliquely towards the base as a result of the narrowness of the margin of the body. These plates are covered by large and unequal granules; some of these granules are a little larger than the others, but these are never developed into true tubercles. These granules become much finer on the adjacent borders of the plates, while they are, on the contrary, more prominent on the external border. These marginal plates carry small pedicellariae; generally there is only one pedicellaria on each plate, but they may be rather frequently missing altogether.

The triangular ventral areas are covered by large plates, the borders of which are not very clearly defined, but which, however, it is possible to easily count on account of the presence of the large valvular pedicellariae which each one of them carries.

There is at first a series adjacent to the ambulacra and which is continued up to a short distance from the extremity of the arms, towards the thirteenth ventral marginal plate; the second row extends up to the ninth marginal; the other plates, which are very numerous, are not disposed in quite regular rows. The size of these plates naturally decreases towards the extremity of the arms and towards the ventral marginal plates. The plates closely adjoining the ventral marginal plates in the inter-radius are particularly reduced and their contours are absolutely indistinct. Each plate contains a large, valvular pedicellaria which occupies almost its entire length, and which is surrounded by a row of very large granules; these granules which are a little widely spaced out on the plates of the internal row, become finer and more close-set as the ventral marginal plates are approached until they become entirely contiguous. The pedicellariae are generally oriented parallel to the median inter-radial line, but a few, however, are exceptions. The larger ones are about 4 mm. in length.

The ventral marginal plates are large, but they are scarcely distinct from the ventral lateral plates; they are separated from one another by very narrow interspaces. They correspond to the dorsal marginals for the most part of the length of the arms, but towards the extremity of the arms, there are two or three supplementary plates, consequent on the elevation of the arms towards the dorsal side at their extremity.

The plates are uniformly covered with granules which are at first very fine, identical to those of the large latero-ventral plates to which they are connected, then they become slightly larger and a little prominent towards the external border, even as those of the

dorsal plates, at least on the four or five first plates. The ventral marginal plates always project out over the dorsals underneath, and they are separated from these latter by a rather large and well marked groove, especially on the margins of the disk. Amidst the granules there are to be found rather short, valvular pedicellariae, about one or two per plate.

The ambulacral grooves are widely open and the podia project outside with their large, terminal suckers. The adambulacral plates are small and straight, a little shorter than those of the first latero-ventral row. The spines are disposed in three rows; the internal row contains five spines disposed in the form of an arch on the internal and convex border of the plate; the spines are cylindrical with the extremity obtuse and the median ones are larger than the others. The second row is generally formed by three large, erect spines, as long as the preceding ones, and attaining the same level; outside this there are two or three spines forming a less regular row, shorter than those of the second row and resembling rather the neighbouring granules of the ventral surface.

The teeth carry on their free margin about ten spines which continue those of the internal ambulacral row and which become especially larger as one approaches the proximal extremity of the teeth; immediately within, there is a second row of about five to six strong, elongated and somewhat pointed spines. Finally, towards the suture, is found a series, more or less regular, of four to five large granules, which pass on to those of the ventral surface.

This species has been recorded from the East Coast of India, where it has been collected from the Ganjam Coast in Orissa, from the Madras Beach and from Kilakarai in the Ramanathapuram District in South India.

Specimens in the collection.—Two specimens of this species are represented in the Museum Collection, one in the Reference Collection and the other mounted and exhibited in the Gallery.

(i) One large, wet-preserved specimen contained in the Reference Collection.

Locality: Kilakarai, Ramanathapuram District, at a depth of four fathoms.

This is a large specimen, dark greyish brown above and pale, sandy brown below. The dorsal surface is covered with scattered whitish tubercles, larger and more widely spaced on the disk and more close-set and smaller and granular on the surface of the arms. The dorsal marginal plates are large, whitish brown, rectangular, higher than broad and are covered with numerous granules of uneven size. The tips of the arms are curved upwards. The arms are broad and merge broadly with disk. The dorsal surface is slightly convex and the ventral surface is flat.

The ambulacral grooves on the ventral side are broad and the podia are large, and distinct and suckered at their tips. The plates on the large, triangular ventral areas carry each one a valvular pedicellaria surrounded by close-set granules. These pedicellariae are oriented mostly parallel to the interradial line. The ventral marginal plates also carry one or two valvular pedicellariae each.

Measurements:

R = 86 mm.

r = 55 mm.

Overall diameter from tip of one arm to the tip of the opposite arm (not consecutive arm) ... 160 mm.

Dorsal marginal plates are 14 in number, and the ventral marginal plates 16 in number.

The specimen is in a good state of preservation.

(iii) One slightly smaller, wet-preserved specimen, exhibited in the Gallery.

Locality: Ganjam Coast, Orissa State.

The specimen is faded nearly completely dirty whitish. The aboral surface is covered with scattered, rounded tubercles of irregular size. The disk is large and the arms are broad, short and not sharply demarcated from the disk. The tips of the arms are broadly rounded and blunt. The dorsal and ventral marginal plates are large, oblong and covered with numerous small granules. On the ventral side, the slit-like valvular pedicellariae are distinctly seen on the ventral plates, especially on the rows of plates adjoining the ambulacral grooves.

Colour: The marginal plates are whitish, while the rest of the surface is dull dirty whitish or greyish white.

Measurements:

R = 69 mm.

r = 45 mm.

Overall tip to tip diameter: 124 mm.

Anthenea rudis Koehler.

FIGURE 67.

Anthenea rudis, Koehler, R., "Shallow Water Asteroidea Collected by the Royal Indian Marine Survey Ship 'Investigator'", Indian Museum, Calcutta, 1910, pp. 86-90.

Koehler has described this as a new species in the reference cited. Two specimens from Snod Island, Mergui Archipelago at 12° Lat. and 98½° Long. East formed the basis of this new species. Koehler reports that these two specimens were of small size and undoubtedly not adult ones.

The body is pentagonal, with the sides deeply excavated in such a manner that the arms are distinct and even relatively long, but they are very broad at the base and merged with the disk. Their extremity is rounded. The disk and the arms are not very thick. The dorsal surface may be slightly convex, with the inter-radial depressions rather deep, or the dorsal surface may be almost flattened and the ventral surface slightly convex.

The first carinal plate on each side carries a large, conical tubercle and the granules of the marginal plates are elongated, on the external surface of these plates, in the form of small spines.

The colour of the specimens, during life, is bright yellow, or bright yellowish brown, but the second specimen examined by Koehler is reported to have been slightly damaged and its colour is described as being brown.

The central region of the disk is occupied by the plates, sufficiently large and rounded, among which may be distinguished distinctly a circle formed by five larger inter-radial and five radial plates—a little smaller.

Within this circle there is a second smaller one, comprising five inter-radial plates, larger than the preceding ones. The contours of these plates are not very distinct. The anus is central and is surrounded by granules—unequal and flattened in the form of platelets.

The skeleton of the arm consists first of a carinal row of hexagonal plates of which the first ones are broader than long, and which become, on the contrary, longer than broad in the terminal part of the arms. The first carries a large and thick conical tubercle. There are nineteen carinal plates. On each side, there is first a primary row of latero-dorsal plates which extend up to the last but one carinal plate. The first plates are hexagonal or lozenge-shaped and wider than long, but the subsequent ones become finally longer than broad. Outside this, there is a second series of plates, the plates alternating

with those of the first series. In the inter-radius, and on each side of the inter-radial line which is depressed, there is a series of three pairs of plates; this double row extends between the inter-radial plate described earlier and the marginal dorsal plates and it is formed of plates larger than the others, especially those of the first pair. All these plates are covered by very fine conical granules, widely spaced in the central region, but approaching one another towards the edge to form an irregular peripheral border which contains one or two rows of granules. There are also other larger and rounded granules sometimes single and isolated on each plate and sometimes three or four or even more on each plate, but these granules do not extend beyond the limits of the disk proper, and they do not moreover constitute tubercles. Among the granules, there appear the valvular pedicellariae, well developed, although rather short, especially on the plates of the disk, where they occur along with one or two big granules; these pedicellariae do not occur on all the plates, and they become extremely rare on the arms.

Between the plates there appear numerous pores which are very closely approximated in the central region of the disk; on the arms they constitute sometimes a double row, and are less abundant, but a little larger than on the disk. The madreporic plate is rather large, ellipsoidal and attached to one of the inter-radial plates. It is elongated in the inter-radial direction and presents numerous well marked grooves.

The dorsal marginal plates are well developed and are about eleven in number on each side. Their dorsal edge is united to the lateral edge by a rounded border. The first plate is a little broader than long, rectangular, with the internal and external margins convex. The surface is convex on the first two or three plates and flattened on the subsequent ones. The plates are almost uniform in size till about the ninth; the tenth is shorter, and the eleventh is very small and closely approximated to its counterpart, but yet separated from it by a small carinal plate. The surface of the dorsal marginal plates is covered by granules, rounded and not contiguous, larger in the central region and towards the external border. These large granules, rather protruding and well marked and approaching one another forms a border for the large valvular pedicellariae which each plate carries towards its external border. The granules become longer and more projecting on the plates towards the extremity of the arm. Frequently, one of these granules close to the internal border on the first plates is larger and developed into a little conical tubercle, quite distinct. Often this tubercle is accompanied by a second tubercle which is situated nearer to the ventral border of the plate. These terminal tubercles are at best as big as, and sometimes even a little larger than, those on the first marginal plates. They tend to give the terminal part of the arm a particularly spiny appearance.

The dorsal marginal plates carry each a large, valvular pedicellaria which is placed in the external region of the plate. These pedicellariae are ordinarily vertically disposed, but sometimes they become somewhat oblique; they are at least three or four times longer than broad. They appear very regularly on all the plates up to the eighth or sometimes up to the ninth, but the others are devoid of them.

The ventral, triangular areas are small. The plates which cover them are disposed in longitudinal and transverse rows and are less numerous than the dorsal plates. There is a primary row of these plates, parallel to the adambulacra; the first ones of these plates are large and broader than long. Each of them carries in its middle a very large valvular pedicellaria, surrounded by a row of large, rounded granules, and of which the long axis is at first oblique in relation to the furrow. This row extends up to the sixth marginal ventral plate on the arms; the size of the plates diminishes rapidly and the pedicellariae then become perpendicular to the furrow, but they do not appear on the last plates, for they disappear at the level of the fifth ventral marginal plate. Outside this row, there are two other rows which contain only a few plates each.

The ventral marginal plates are of the same number as the dorsal marginal plates to which they correspond exactly. They are at first a little broader than long, then they become squarish and as long as wide, except the last two ones which are very short. They are covered with granules which are finer and more close set than on the

latero-ventral plate and they carry a large, valvular pedicellaria identical to that of the dorsal marginals and the direction of which is variable. These pedicellariae occur up to the tenth plate, and sometimes the single pedicellaria is replaced by two or three smaller pedicellariae disposed irregularly. The granules of the ventral marginal plates become more prominent towards the external border.

The adambulacral plates are small and squarish; they are smaller than the latero-ventral plates of the first row, and three of the first correspond to two of these. The spines are disposed in three rows. The internal row contains five erect spines parallel to one another, the uniddle one being larger than the others; these spines are cylindrical & a little flattened, with the extremity rounded. The second row presents, in general, three spines, stronger than the preceding ones, particularly the middle one which is larger and a little longer than the others. Outside this occurs a third row, comprising two spines, a little shorter again than the preceding ones, but as thick. Koehler reports that in the second specimen examined by him, the middle spine of the second row is very long and thicker than the adjoining ones and even appears to be the only one in this row, the two lateral spines merging more or less with those of the external row.

The teeth carry on their free border a row of about ten spines, sufficiently well developed, and which become a little thicker towards the proximal extremity. On the ventral surface appear two rows of spines, very short and thick, and resembling very much large granules, numbering about half a dozen per row.

Specimens in the collection: This species is represented by three specimens in the Reference Collection and one exhibited in the Gallery. All are wet-preserved, in alcohol.

1. Reference Collection.

(i) One specimen, moderately small. Locality: Kilakarai, Ramanathapuram District.

The arms are well marked and distinct from the disk. The disk is flattened. The upper surface is granular. The marginal plates are large and distinct. Five radiating linear depressions converge towards the centre (but not reaching the centre), on the upper surface, from the inter-radial angles. The plates bordering on the marginal plates are larger and more conspicuous than the remaining ones.

Colour: Dirty whitish brown.

Measurements:

$R = 23$ mm.

$r = 10$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 45 mm.

(ii) One specimen, slightly larger. Locality: Kilakarai, Ramanathapuram District.

The disk is flattened and slightly concavely depressed at the top and the arms are slightly up-turned towards their tips. The dorsal surface of the disk is covered with uniformly large, rounded plates, closely crowded, among which a circle may be distinguished, formed of five larger inter-radial and five radial plates—a little smaller. Unlike as in the preceding specimen, the dorsal plates are throughout well developed and large in this specimen and not adjacent to the marginal plates only. The marginal plates are large and squarish or rectangular.

Colour: On the dorsal surface, the area within the marginal plates is darker brown. The marginal plates are pale whitish brown or creamy white. The under surface is whitish and the ambulacral grooves dark brownish.

Measurements: $R = 25$ mm.

$r = 13$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 45 mm.

(iii) One specimen, somewhat smaller than the two preceding ones.

Locality: Kilakarai, Ramanathapuram District.

In this specimen, the tips of three of the arms are badly mutilated and one of the remaining two arms is slightly broken.

Colour: The dorsal surface is paler brown than in the preceding specimens and shows distinctly the inter-radial linear depressions as in the first specimen mentioned above. The under surface is dirty whitish grey.

Measurements: $R = 20$ mm.

$r = 11$ mm.

The overall, tip-to-tip diameter could not be determined accurately in this specimen as the tips of the arms are not complete in this specimen.

The specimen is very brittle and fragile. The ambulacral grooves are almost completely occluded by calcareous sedimentation of the worn out granular patches.

2. Gallery Collection.

(iv) One specimen, mounted in alcohol and exhibited in the Gallery.

Locality: Kilakarai, Ramanathapuram District.

The specimen is rather small, bleached almost uniformly whitish. The dorsal and ventral marginal plates are rather broad and squarish. The aboral surface is covered with small rather closely crowded, scattered granules. The surface presents a somewhat granular or pitted appearance. The ventral marginal plates each bears one (or sometimes two) valvular pedicellariae. The arms are slightly longer (in proportion to the disk) and more sharply marked off from the disk than in specimens of *Anthenea pentagonula*. The tips of the arms are bluntly rounded and slightly curved upwards.

Measurements: $R = 23$ mm.

$r = 11$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 46 mm.

Anthenea pentagonula (Lamarck).

FIGURE 68.

Asterias pentagonula, Lamarck, Anim. sans Vert., II, p. 554.

Goniodiscus pentagonulus, Muller and Troschel, System der Asteroidea, 1842, p. 57, pl. 4, fig. 2.

Anthenea Chinensis, Gray, Annals and Magazine of Natural History, 1840, p. 279.

Anthenea Chineosis, Gray, Proc. Zool. Soc. London, 1847, p. 77.

Anthenea Chinensis, Gray, Synopsis of the Species of Starfish in the British Museum (with figures of some new species), 1866, p. 8.

Anthenea pentagonula, Bell, "On Echinoderms from Tuticorin", Proc. Zool. Soc. London, 1888, p. 384.

The dorsal surface is obscurely netted, rather chaffy, with scattered, truncated tubercles in rather diverging lines. The marginal plates are not tuberculated. The arms are broad, being half the length of the width of the body. A very large, two-lipped pore is present on each plate of the ventral surface. The ratio of the inter radius (r) to the radius (R) is as 1 : $1\frac{1}{2}$ – $1\frac{3}{4}$.

The number of marginal plates on each arm is about 12–13. The angles between the arms are flat and rounded. The ambulacral spines are disposed in three rows. In the innermost row, there are five spines on each plate; these are as long as the ones in the second row; in the second row, there are three on each plate of which the one in the middle is the longest. On the outside of this row is another third incomplete row consisting of shorter spines. The granules of the plates on the oral side are in the form of small cylinders. Towards the margin, these granules become smaller and are crowded together. On the margin itself they are again as small as the ones on the oral side. The granules of the plates on the aboral side are very small and are not crowded together. Besides on the aboral side, there are small, short tubercles which are arranged in rows running towards the tip of the arms. Here three central rows of such tubercles may be generally distinguished. Of these the middle one is incomplete and sometimes even absent. The poriferous zones, comprising the plates bearing the large, two-lipped pores on the ventral surface are disposed very irregularly. Valvular pedicellariae are present on the oral side, on both the rows of the marginal plates and on the aboral side. The ones on the oral side are very large and are found along the entire length of the plates. On the lower marginal plates they are smaller, but bigger than the ones on the upper marginal plates and on the aboral side.

The colour is generally reddish blue on the dorsal surface and paler ventrally.

The type locality of this species is China.

Muller and Troschel in their original reference cited have recorded specimens of this species from the Museums of Berlin, Paris and Leyden, and Gray (*loc. cit.*), from the British Museum (Natural History), London.

Although this species has been recorded originally only from China and Japan (Muller and Troschel, *loc. cit.*, Gray *loc. cit.*), this species has a wider range of distribution and has been recorded even from Tuticorin (Bell, *loc. cit.*), and from Pamban in the Gulf of Manaar (in the Madras Museum Collection).

Specimens in collection.—Two dry-preserved specimens are represented in the Museum collection; they are exhibited in the Gallery.

Locality: Pamban, in the Gulf of Manaar.

These two specimens are uniformly earthy brownish. The aboral surface is covered with scattered rounded tubercles of irregular size and the pedicellariae on the ventral plates are distinctly seen. The arms are curved upwards near their tips and are broadly rounded.

The dorsal and ventral marginal plates are large, oblong and granules. Each of the ventral marginal plates carries two or three valvular pedicellariae.

Measurements: (of the larger specimen):

R = 83 mm.

r = 54 mm.

Overall diameter from tip of one arm to tip of the opposite arm : 156 mm

Genus *Stellaster* Gray.

The body is depressed, covered with large, flat, regular, six-sided plates; the margin bears two rows of large tesserae; the lower row with a series of compressed, mobile spines. This genus belongs to a group of genera of the family Goniasteridae in which the pedicellariae are bivalved and the body is covered by a membrane obscuring the ossicles except the marginal ones.

This genus is represented in the Museum Collection by two species, *Stellaster belcheri* and *Stellaster incei*. In the former, the tubercles are larger and fewer and the arms are more slender having only a single series of plates between the marginal ones.

***Stellaster belcheri* (Gray).**

FIGURE 69.

Stellaster belcheri, Gray, Synopsis of the Species of Starfish in the British Museum, (with figures of some of the new species), 1866, p. 7, pl. 7, fig. 1.

Stellaster belcheri, Gray, Proceedings of the Zoological Society of London, 1847, p. 76.

Stellaster belcheri, Sladen, "On the Asteroidea and Echinoidea of the Korea, Straits", Journ. Linn. Soc. London, XIV, 1879, p. 430a (Korean Straits).

Stellaster belcheri, Fisher, "Starfishes of the Philippine Seas", Bull. United States National Museum, 100, Vol. 3, 1919, p. 326.

The dorsal surface is convex, with two or three large, conical tubercles on the line extending to the centre of the arms. The arms are slender, tapering, rather larger than the diameter of the disk.

This species is intermediate between *Stellaster Childreni* and *S. incei*, having the white colour and the slender arms of the former and the convex back and tubercles of the latter; but the tubercles are larger and fewer, and the arms are more slender, having only a single series of plates between the marginal ones. Gray (*loc. cit.*, 1866), reports that there were two specimens in spirit and one dried specimen in the collection of the British Museum (Natural History). The localities from which this species was originally recorded were Amboina and New Guinea.

Specimens in the collection.—Three wet-preserved specimens, one in the gallery collection and two in the Reference Collection, are represented in the Museum Collection.

1. Gallery Collection.

(1) One wet-preserved specimen, preserved in alcohol, exhibited in the Gallery. Locality: Ganjam Coast, Orissa State.

The specimen is bleached. The dorsal marginal plates are large, more or less longish and rectangular with rounded upper margins. The dorsal marginal plates are more or less completely white. The aboral surface is pale, dirty greyish white, and bears small, irregularly scattered, round white tubercles on the disk. The middle row of plates along the back of each arm are enlarged and more or less hexagonal. On the under side, the ambulacral grooves are narrow and the ventral marginal plates large and whitish. The large, triangular inter-radial spaces between the ambulacral grooves and the inner edges of the ventral marginal plates has large, more or less rounded or squarish or hexagonal plates. The ventral marginal plates bear a series of fine, white spines at their edges, but many of these spines are lost in the present specimen. The starfish is flattened and depressed and only slightly convexly elevated over the region of the disk, the inter-radial spaces on the aboral surface being somewhat conspicuously depressed. The inter-radial margins are deeply concavely curved.

Measurements: R = 54 mm.

r = 24 mm.

Overall tip to tip diameter: 95 mm.

II. Reference Collection.

(2) Two wet-preserved specimens (probably from the Madras Coast), purchased from the Ennur Fisheries Biological Station in 1950.

Of these two specimens, one is larger and one more dark-coloured, being of a somewhat variegated brownish grey colour above and the other smaller and almost uniformly white. The arms are tapered and narrow towards the tip and the inter-radial spaces deeply concavely excavated. The marginal plates are large and conspicuous and the plates on the dorsal and ventral surfaces of the disk and arms are also large more or less hexagonal, and clearly visible.

Measurements: (i) of the larger specimens:

$R = 38$ mm.

$r = 15$ mm.

Overall tip to tip diameter: 66 mm.

(ii) of the smaller specimen:

$R = 25$ mm.

$r = 11$ mm.

Overall tip to tip diameter: 45 mm.

Stellaster inaei Gray.

FIGURE 70.

Stellaster inaei, Gray, Proc. Zool. Soc. London, 1847 p. 76.

Stellaster gracilis, K. Mobius, Neue Seesterne d. Hamb. u. Kiel. Mus. 1859, p. 12 Taf. i, figs. 3, 4.

Stellaster gracilis, Mobius, Neue Seesterne des Hamburger und Kieler Museums Abhandl. a. d. Gebiete Naturw. hrsg. v. ds., naturwiss. Verein, Hamburg, Vol. 4, figs. 3 and 4.

Stellaster inaei, Gray, Synopsis of the Species of Starfish in the British Museum (Natural History), 1866, p. 7, pl. 5, fig. 1.

Stellaster squamulosus, Th. Studer, Abhandl. Akad. Wiss. Berlin, 1884, iv, p. 33, Taf. iv., fig. 6.

Stellaster inaei, Sladen, Report on the Asteroidea Collected by H.M.S. Challenger, Zoology, XXX, 1889, p. 322.

Stellaster inaei, Döderlein, L., Semon's Zool. Forsch. in Auster. & C. Bd. V, f. 3, 1896, p. 337.

Stellaster inaei, Döderlein, L., Ibid., 4, 1898.

Stellaster inaei, Bedford, "On Echinoderms from Malacca and Singapore", Proc. Zool. Soc. London. 1900, p. 295.

Stellaster inaei, Koehler, R., Shallow Water Asteroidea collected by the Royal Indian Marine Survey Ship, "Investigator" Indian Museum, Calcutta, 1910, p. 80.

Stellaster inaei, Brown, Echinoidea and Asteroidea from the Mergui Archipelago and Maskos Islands, Lower Burma, Proc. Roy. Phys. Soc., Edinburgh, XVIII, 1910, p. 31.

Stellaster inaei, Simpson and Brown, Asteroidea of Portuguese East Africa, etc., Proc. Roy. Phys. Soc., Edinburgh, XVIII, 1910, p. 50.

Stellaster inaei, Fisher, "Starfishes of the Philippine Seas," Bull. United States National Museum, 100, Vol. 3, 1919, p. 326.

Fisher (*loc. cit.*), reports, commenting on the Philippine specimens of *Stellaster incei* that Sladen considers *Stellaster incei* and the preceding species, *Stellaster belcheri*, to be growth stages of one and the same species. Fisher reports that the specimens from Philippines collected by the *Albatross* are mostly small, and, as in the case of Döderlein's specimens from Thursday Island (*loc. cit.*, 1896), are referable to "*belcheri*".

However, the specimens of these two species contained in the collection of the Madras Museum, collected from the East Coast of South India, are sufficiently distinct, and hence, in the absence of more specimens representing intermediate stages, the two species are treated as distinct and described as such in the present account, but it is quite probable, as Fisher admits, that the two are one and the same species and that "*belcheri*" represents the earlier stages in the growth of the species "*incei*".

The granules are fine, bead-like and well spaced out and the membrane very thin. The furrow comb consists of seven or eight rather slender spines, the median more compressed than the laterals, and all webbed for half their length. The sub-ambulacral spines are two to four in number, flattened, round-tipped and unequal and arranged in a longitudinal series. Immediately behind the adoral furrow spine is often a prominent pincer-shaped slightly tapering pedicellaria. In very small specimens the subambulacral spines are represented by a row of granules.

The abactinal plates in adult and sexually mature specimens are large, five to seven in each inter-radius being the largest, and on the margin bordering the papular areas, scalloped. The carinal plates have two short lobes on either side, and the adradial plates on the rays have two lobes also on either side, which as seen from below, overlie the edges of the carinal and the other adjacent longitudinal series. In the central area of the disk, the plates have five or six more prominent lobes. There are three or four papulae to each pore between the lobes of the plates.

The gonads, in mature specimens, form a single large cluster, one on each side of the membranous interbrahcial septum, ten in all.

The type locality of this species is cited as "North Australia" by Gray.

The body is purplish, minutely granular; the back bears scattered, conical, convex tubercles, those down the centre of the arms being the largest. The lower marginal plates are flattish. This species was originally recorded from North Australia, but it seems to be widely distributed in the Indo-Pacific Region, being known from Singapore and from the Indian Coasts.

This species is very much like *Stellaster Childreni* Gray (Annals and Magazine of Natural History, 1840, p. 276; Muller, Aster., 62 128, t. 4. fig. 3, *Asterias equestris* Retzius Diss 12); but it is purplish when dry; the back is tuberculated. The whole surface is minutely granular, while the Japanese species (*Stellaster childreni*) is always white, the back smooth, and the granules on the surface are so minute and thin that they are very easily eroded, and the lower marginal plates are more convex and the central ones much larger than the others.

Koehler (*loc. cit.*), observes that the specimens examined by him in the Indian Museum Collection present many variations, evident at first on the length of the ambulacral spines, which in specimens of small or lesser size, are perhaps more or less developed, and next on the pedicellariae. These are more or less numerous, the number differing in different individuals. Mostly one observes specimens in which the pedicellariae are all alveolar, with the valves straight and some slightly projecting, and others in which the pedicellariae are clearly valvular, with the valves longer than broad. Finally, certain specimens examined by Koehler contained both the alveolar and valvular pedicellariae with the transitional stages between the two forms. These

variations indicate that the species cannot be separated exclusively on the basis of the forms of the pedicellariae even as in the case of *Goniodiscus forticulatus* in which one observes sometimes alveolar pedicellariae and sometimes valvular pedicellariae.

There are also considerable differences in the number, the position and the dimensions of the tubercles on the dorsal surface.

Bedford (*loc. cit.*), records that this is perhaps the commonest species of Starfish found on the Coasts of Singapore. It lives at a depth of three to ten fathoms on mud or shelly gravel around Singapore. Bedford has recorded a specimen of this species infested by two specimens of the parasitic Mollusc *Thyca*; they were found fixed close together on the abactinal side.

In this species, the black pigment is developed on a variable number of the ventro-lateral plates; this is said to completely disappear in specimens preserved in alcohol, but is retained in specimens preserved in formalin. In only a few specimens, the under side of the starfish is pigmented. In the majority of cases the under side is pale or white. As in the case of the black pigment often found lining the body cavity of the Holothurians, the use of the black pigment in this species of starfish on the ventro-lateral plates is not properly understood.

The distribution of this species mostly ranges from Singapore to Australia and thence extends northwards to the Korean Straits. But it has been recorded also from the Ganjam and Orissa Coasts and the Coast of Vizagapatnam on the East Coast of India (Koehler, *loc. cit.*).

Fisher (*loc. cit.*), cites the range of distribution of this species as follows:—

East to the Mozambique Coast (Simpson and Brown), India and Ceylon, Mergui Archipelago. Sumatra and Singapore, Philippines to Korea (? Sladen), south to New Guinea, Arafura Sea, Torres Strait, North, North-East and South Australia. The bathy-metric range extends from 3 to 74 fathoms, usually under 50 fathoms.

Specimens in the collection.—Two wet-preserved specimens in the Reference Collection (preserved in spirit). Locality: Santapalli, "Madras Presidency" (Tamil Nadu).

The specimens are fairly large, pale creamy brown in colour above, and creamy white below.

One of the specimens has one of its arms broken towards its tip.

The specimens are convexly arched above. The plates on the dorsal surface are irregularly polygonal and varied in size and fit in closely as in a mosaic. There are a few whitish, small prominent, conical or rounded, raised tubercles. The marginal plates are large, whitish and longer than broad, those on the inter-radius being the largest. On the ventral side, the ambulacral grooves are narrow, and bounded by an internal row of small spines bordered externally by a row of larger, whitish, flattened spines. The marginal plates on the ventral surface are as large as those on the dorsal surface and are white and rectangular, being higher than broad. The ventral plates between the marginals and the ambulacral grooves are irregular in shape and size, more or less rounded and closely juxtaposed.

Specimen (i): Entire, with the tips of the arms almost intact.

Measurements: $R = 56$ mm.

$r = 24$ mm.

Overall diameter (from tip of one arm to tip of opposite arm): 106 mm.

Even in this specimen, the very extreme tips two of the arms are broken.

The raised tubercles on the dorsal surface are few and scattered.

Specimen (ii) One entire arm is broken and the tips of two of the other arms are also broken.

Measurement: $R = 61$ mm.

$r = 25$ mm.

This specimen is slightly larger than the preceding one. The groups of small pores present in depressed areas on the margins of the plates on the dorsal surface are clearer and more well defined in this than in the preceding specimen.

The raised tubercles on the dorsal surface are more numerous and scattered.

The specimens, during glife, are purplish. The surface is minutely granular. The ventral marginal plates are somewhat flattened.

Genus *Goniodiscus* Muller and Troschel.

The body is in the form of a pentagonal disk which is flattened on both sides. There are two rows of large marginal plates, the upper surfaces of which are completely granulated. The abactinal area is covered with stellate plates, leaving wide interspaces for the passage of papulae. The upper and lower series of marginal plates meet each other along the thick margin, and due to the presence of this double series of marginal plates, the pentagonal disk comes to possess a definite, vertical lateral surface. The oral and aboral areas are inlaid with granules. The anus is subcentral.

A single species, *Goniodiscus granuliferus* (Gray) is represented in the Museum Collection.

Goniodiscus granuliferus (Gray).

FIGURE 71.

Anthenea granulifera, Gray, Proc. Zool. Soc. London, 1847, p. 77.

Anthenea granulifera, Gray, Annals and Magazine of Natural History, 1847, p. 198.

Anthenea granulifera, Gray, Synopsis of the species of Starfish in the British Museum (Natural History), (with figures of some new species), 1886, p. 9; pl; v, fig. 2.

Goniodiscus granuliferus, Sladen, Asteroidea, "Challenger" Reports, Zoology, XXX, 1889, p. 754.

The body is in the form of a thick, pentagonal disk, with the arms fairly well developed, broad and blunt and with the inter-brachial areas broadly concavely curved and not angular. Both surfaces are covered with small, roundish granules, and the back is provided with rather convex ossicula. One or more small two-lipped pores are present on some of the ossicula of the oral surface; the back is sub-tubercular and the ossicula are all covered with large, roundish granules.

The arms are as long as the diameter of the body; the back of the arms is furnished with one or two scattered tubercles.

In some specimens, the back is furnished with a blunt tubercle on the centre of each of the ossicula of the middle of the back. This condition appears as a well marked variation in this species.

This species is easily distinguished from the closely related species, *Anthenea tuberculata*, by the smaller granules on the surface, the length of the arms, and the small size of the two-lipped pores; those of the dorsal surface are very minute.

This species occurs in the Indo-Pacific Region over a wide area. Sladen (*loc. cit.*), has specifically recorded it from the Chinese Seas in his "Challenger" Reports.

Specimens in the collection.—One dry-preserved specimen is exhibited in the Gallery. Locality: Pamban, Gulf of Manaar.

Although this specimen has been collected from Pamban, this species has not been previously recorded from this area and has not been mentioned in the Bulletin of this Museum on the Littoral Fauna of Krusadai Island, in the Gulf of Manaar, Vol. I, No. 1, 1927. This species is therefore being recorded here for the first time as occurring in the Pamban area in the Gulf of Manaar.

The specimen is moderate-sized, dark rufous-brown. The dorsal marginal plates are large, oblong, being much higher than wide. Both upper and lower surface are covered with small roundish granules. The dorsal surface bears rather convexly raised ossicula. The median rows of plates along the back of each arm (running from the centre of the disk) are slightly enlarged and more or less hexagonal. The central portion of the disk bears a few small, rounded, scattered tubercles, the arms are short, thick and broad at the base, merging broadly with the disk. The arms are as long as the diameter of the disk. The lips of the arms are broadly rounded, blunt and obtuse.

Measurements: R = 52 mm.

r = 31 mm.

Overall tip to tip diameter: 104 mm.

Family OREASTERIDAE

(= PENTACEROTIDAE.)

The family Oreasteridae was formerly known by the more familiar name, Pentacerotidae. It is characterized by the reticulate skeleton enclosing papular areas in its meshes. The body is supported by roundish or elongated plates covered with a smooth or granular skin, pierced with minute pores between the tubercles.

This family includes moderate-sized to large-sized species of Sea stars. The body is of a broad shape with short, broadly based arms which may sometimes be reduced to such an extent as to be represented by merely angles at the periphery of the pentagonal disk of the body. Tubercles are typically borne on the nodes of the reticular network, specially along the carinals, and may attain a considerable size. Large marginal plates are present, but are often concealed from view from above.

Most of the species belonging to this family are confined to the Indo-Pacific Region and almost all are littoral forms occurring in the warmest tropical waters.

The family Oreasteridae, as originally conceived by Döderlein included a number of genera belonging to the family Goniasteridae, and the family Oreasteridae, as at present constituted and accepted, therefore, more strictly corresponds to the subfamily Oreasterinae of Döderlein which includes the typical genera now regarded as properly belonging to the Oreasteridae.

According to the earlier system of classification, which is by far the more familiar and had been followed till recently by most authors, only two genera of this family, namely, *Oreaster* and *Asterodiscus* were represented in the Madras Museum Collection, the former by three species and the latter by one species. All the specimens of these species in the Museum Collection have been collected from Pamban, Tuticorin and other localities in the South on the East Coast.

In *Asterodisus* the body is somewhat depressed, the arms short and rounded, and the body is covered with numerous close-set, flat-topped, unequal small tubercles, and the whole body itself actually appears to be covered by a rough, warty skin. The marginal plates are concealed except for two conspicuous ones of the aboral surface of the tips of the arms.

In *Oreaster* on the other hand, the body is convex above, the arms proportionately longer and the aboral surface bears numerous immovable, more widely spaced tubercles, including a carinal row. The marginal plates are evident, though not conspicuous.

Actually, however, Döderlein who made a detailed study of this group (in this Monograph on the Oreasteridae and in his treatise on the Oreasterinae of the Siboga Expedition), has established a new genus, *Protoreaster* (based on certain minor morphological details), for the reception of the species *O. linckii* and *O. nodosus* and hence the species *linckii* should strictly speaking, be referred to as *Protoreaster linckii*.

Similarly, the familiar species formerly more commonly known as *Pentaceros hedemanni* and which was later more appropriately referred to the genus *Oreaster* and designated as *Oreaster hedemanni*, is now found to be referred to by Döderlein to the genus *Pentaceraster* and described under the name of *Pentaceraster multispinus* which has since been established as a synonym for *Oreaster hedemanni*. Hence the species referred to in the earlier Bulletin of this Museum ("Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bulletin, Madras Government Museum, Natural History, I, No. 1, 1927), as *Pentaceras hedemanni* is described under the currently accepted name of *Pentaceraster multispinus* in the present account.

In the Madras Museum Collection, the three species formerly clubbed together under the single genus *Oreaster*, and referred to as *O. hedemanni* (*Pentaceras hedemanni*), *O. thurstoni* and *O. linckii* have therefore now been split up according to their correct systematic position and assigned to different genera and designated as *Pentaceraster multispinus*, *Oreaster thurstoni* and *Protoreaster linckii* respectively and have been described accordingly under these respective genera in the present account.

Specimens of the first two species represented in the Museum Collection have been collected from Pamban in the Gulf of Manaar and those of the third species from Tuticorin.

These three species, although assigned to different genera, are still somewhat closely related, and may be distinguished from one another as follows:—

1. Spines very big and robust, mostly very long, thin and pointed; a distinct apex central areas are formed within the five apical plates. Colour reddish. Sometimes the spines are thick, and bluntly pointed:

Protoreaster linckii
(= *Oreaster linckii*).

- Spines shorter or poorly developed and often reduced into tubercles; apical area not distinct as above; colour more variable, sometimes purplish bluish reddish grey, etc., with more variegated patterns:

2.

2. Dorsal surface of the disk strongly raised and projecting; tubercles relatively large and well developed. Adambulacral spinulation not triplacanthid:

Pentaceraster multispinus

- Dorsal surface of disk only moderately elevated; spines except the five apicals, as a rule poorly developed. Adambulacral spinulation is triplacanthid (i. e., in three rows):

(= *Oreaster hedemanni*).

.. *Oreaster thurstoni*

Genus *Pentaceraster* Döderlein.

The body is more or less raised towards the centre of the disk. The arms are of moderate length ($R = 2$ to $3 r$). Two rows of dorso-lateral plates extend into the free arms. Nearly all the dorsal and marginal plates may be enlarged. They may be spiny, knobby, or in the form of conical, tubercle-like structures. The apical spines are the longest and, as a rule, with naked tips. The dorsal plates are joined together by numerous reticularia (most often about 4 to 6 around each plate). The entire dorsal side and the marginal plates are covered by a nearly uniform, fine layer or granules. Rarely, the granules at the tips of the bigger spines are modified into polygonal, plate-like structures. The original, rounded granules which cover the ventro-lateral plates become, especially, in the case of bigger specimens, exceptionally long and form a rough, sometimes spiny surface. The pedicellariae on many of the adambulacral plates, on most of the ventro-lateral plates of the 1st row and also on other skeletal plates and supra-ventrals, have alveoli. Two to three rows of spines are present along the ambulacral grooves, the innermost row having 6-11 thin spines and the 2nd row 2-6 very thick (big) ones. Often a third row also makes its appearance sooner or later. In normal-sized specimens of all species of this genus, there are apical spines and a few carinal spines, and lower marginal spines are always present at the tips of the arms. Most often, central and dorso-lateral spines are present at least on the disk. There are also found generally the upper marginal spines in the middle of the arm and the lower marginal spines in the inter-radii. The last upper marginal plates near the tips of the arms are practically without spines.

The genus *Protoreaster* is sharply demarcated from the genus *Pentaceraster* by the fact that the outer marginal plates and also most of the bigger spines are covered with an uniform, fine, granular layer, and also further by the fact that this layer on the ventro-lateral plates is very uneven and rough, and has the tendency to become spiny and that in bigger specimens a third row of groove spines appears, and above all by the presence of countless inner reticularia.

The genus is by far the richest in so far as the number of species is concerned, under the family Oreasteridae, and is distributed throughout the whole of the tropical Indo-Pacific Region, from Mozambique up to Panama and from Liukin Islands up to Queenaland.

A single species of this genus, namely, *Pentaceraster multispinus* (formerly more familiarly known as *Pentaceras hedemanni*, and more recently as *Oreaster hedemanni*), is represented in the Museum collection.

Pentaceraster multispinus (von Martens).

FIGURE 72.

Pentaceros nodosus, Gray, Annals and Magazine of Natural History, 1840, p. 277, Billiton.

Oreaster muricatus var. *multispina*, von Martens, 1866, Arch. f. Naturg. Bd., 32, p. 79 and 81, Flores.

Oreaster hedemanni, Lutken, 1871, Videnskab. Meddel., p. 255, 263, Billiton.

Oreaster hedemanni, Bell, F.J., "On the species of Oreaster" Proc. Zool. Soc. London, 1884, p. 71.

Oreaster grayi, Bell, 1884, ibid., p. 83

Pentaceras Hedemanni, Koehler, "Shallow Water Asteroidea Collected by the Royal Indian Marine Survey Ship 'Investigator'", Indian Museum, Calcutta, 1910, pp. 96-98; pl. x, fig. 6; pl. xi, fig. 7, Billiton.

Pentaceraster multispinus, Döderlein, 1916, Zool. Jahrb. Syst. Ed. 40, p. 430.

Pentaceros hedemanni, Gravelly, "Littoral Fauna of Krusadai Island, (in the Gulf of Manaar)", I, No. 1, 1927, p. 169.

Pentacaster multispinus, Döderlein, Siboga Expeditie, Oreasterinae, XLVI, 1936, p. 336; p.l. xxiv, fig. 12; pl. xxvi, fig. 1-3.

This species had long been known by its more familiar and commonly accepted name *Pentaceros hedemanni* and is one of the commonest species of the larger type of Starfish met with in Mandapam, Pamban, Rameswaram and other localities around the Gulf of Manaar, but Döderlein (*loc. cit.*), has established that this is only a synonym for *Pentacaster multispinus* which name has priority over the former.

Pentaceros hedemanni was originally described by Lutken after a specimen collected from Billiton. Koehler (*loc. cit.*), reports that he had been able to study the type specimen of this species which is found in the Copenhagen Museum. The specimen is reported to be in a very good state of preservation and is preserved in alcohol. It is not of a very large size, its measurements being cited as : R = 60 mm.; r = 24 mm., and Lutken thought that it was a young specimen.

The dorsal surface is very strongly raised and projecting, while the ventral surface is excavated, and the animal, when placed on a horizontal support rests only on the extremities of the arms. The disk is relatively large. The arms are merged with the disk at their base which is very large, but they are nevertheless very distinct. They narrow down rapidly up to the extremity and their form is triangular. The dorsal carina is well marked. The five apical tubercles are sufficiently well developed, and they terminate in blunt points. They form a pentagon of rather small diameter and which bears in its middle a tubercle, slightly developed. From each apical tubercle, proceeds a carinal series of smaller tubercles which do not appear on all the plates and which are wanting on the last four or five plates. These tubercles are about seven or eight in number on each arm and their sizes diminish regularly as one moves further away from the disk. On each side of the carinal row, appears a primary row of plates very close to the carinals; next, outside this, there is a second row which does not pass beyond the middle of the arm and disappears towards the fifth dorsal marginal plate. Each plate is joined to its neighbours by about half dozen small tubercles which together form very regular patterns at least at the base of the arms. The five apical plates are similarly bounded to their adjacent plates by eight projecting and elongated trabecules, each group forming a very regular and elegant pattern. Likewise, the air pores sunk in between these ossicles are very clearly defined as noted by Lutken. Certain plates of the latero-dorsal row are raised into tubercles, but these are not very numerous; there are two to four such tubercles on the first row and one or two only on the second. The madreporic plate close to the apical pentagon, is rather small and almost circular.

The poriferous areas are small, but numerous and very distinct; there are four rows of such areas at the base of the arms. The first row, between the carinal plates and the first latero-dorsal series, includes a double series of alternate areas, small, rounded or irregularly polygonal, well defined, and extending up to the extremity of the arms. The third series is only distinct at the base of the arms and it is merged with the external areas, which are large and sunk between the dorsal marginal plates. In addition, again in the middle of the inter-radial rows, there are some poriferous areas which do not belong to any distinct series. Within the apical pentagon, there occurs, equally, about twenty areas, rather unequally separated by irregular projecting ossicles.

The dorsal marginal plates, numbering about fifteen, constitute a very distinct border. They are rather projecting, a little almost as long as broad and narrowed in their internal half for allowing place to the poriferous areas of the external row. The first plate of each series is generally smooth and plain, and more frequently the second is equally so. The succeeding ones are raised sometimes into a rather projecting tubercle, terminated by a rounded spine, and on each side there are four to six plates thus armed; towards the extremity of the arms, the plates always remain simply convex.

The latero-ventral plates, large and rather less numerous, have quite distinct contours, and they are regularly disposed in series parallel to the adambulacrals; they form evenly transverse rows extending from the adambulacrals to the ventral marginals. The plates of the first series are almost squarish and extend almost up to the extremity of the arms. Those of the second row start from a large, unpaired plate which occupies the middle of the inter-radial areas and they do not pass beyond the fourth ventral marginal plate. A third series extends up to the third ventral marginal plate; finally, a few other series, very short, complete the ventral areas. All these plates are covered with large, flattened granules, becoming smaller towards the border. The valvular pedicellariae appear only on the plates contiguous with the adambulacrals; the larger plates have two the others only one. These pedicellariae are of average dimensions and are placed either perpendicularly or obliquely in relation to the furrow (ambulacral groove).

The ventral marginal plates are quite distinct, and form a rather wide border; they correspond exactly to the dorsal marginal plates. They are a little wider than long and covered with granules, very closely crowded together and very regular, flattened, and identical with those of the ventral plates and becoming smaller towards the border. The pedicellariae are wanting. The two or three first plates carry towards the middle of their external border a small, conical and obtuse spine. The succeeding plates are smooth and spineless; then the spines appear again towards the extremity of the arms, sometimes on one and more frequently on two plates. The terminal spines are a little more developed than those of the first plates.

The internal adambulacral spines are about seven in number and disposed in a triangle. The spines of the external row are two in number; they are rather long, flattened and obtuse at the extremity. Sometimes the number is raised to three, and the oral spine is always smaller. Between the two rows and on the oral side of the plate appears a large pedicellaria with claw. Outside of the second row there are three or even four flattened granules, more or less distinct, and which gradually lead on to the granules of the ventral plates.

This species is widely distributed in the Indo-Pacific Region and has been recorded from several stations covered by the Siboga Expedition as mentioned in Döderlein's Report (*loc. cit.*).

This species is very common at Mandapam, and in moderately shallow water at low tide on the western side of Kutikal Point, lying on the bottom. Dr. Gravelly (*loc. cit.*), reports that only specimens from the former locality were preserved in the Madras Museum collection, but that those from the latter locality were almost certainly identical with them. However, subsequently, a number of specimens of this species have been collected from the lagoons around Krusadai Island and from the shallow mud flats at Kutikal point and added to the Museum collection.

This species is much the largest starfish represented in the Museum Collection, with a big and rather sparsely tuberculated disk and relatively short, thick arms. There are five rather large tubercles arranged pentagonally on the aboral surface of the disk, from each of which a row of tubercles extends to the tip of the corresponding arm.

Specimens in the collection: Two specimens (wet preserved) from Mandapam in the Reference Collection and two specimens (one dry-preserved and one wet-preserved), presumably from Pamban, exhibited in the Gallery collection are represented.

I. Reference Collection —

Two specimens, wet-preserved. Locality: Mandapam, Ramanathapuram District.

One is larger, more or less pinkish orange, with the lower surface very pale, almost whitish, while the other, which is slightly smaller, is dull dirty greyish brown, with the lower surface pale brownish grey and the tips of the short, thick-set arms more sharply curved upwards.

The tubercles and the raised net-work-like pattern of ridges separating the poriferous areas are distinct, more so in the larger specimen.

The ventral marginal plates and the plates on the large triangular areas on the oral surface are profusely covered by small granules. The ambulacral grooves are narrow and the podia with their large, rounded, terminal suckers are distinct and protruding. The dorsal marginal plates are each raised in a rather projecting tubercle terminated by a spine. The oral side is deeply concavely depressed.

Measurements :

(i) of the larger specimen :

R = 85 mm.

r = 42 mm.

Overall diameter from tip of one arm to tip of the opposite arm : 158 mm.

(ii) of the smaller specimen :

R = 73 mm.

r = 37 mm.

Overall diameter from tip of one arm to tip of the opposite arm : 122 mm.

The valvular pedicellariae are present only on the ventral plates which are adjacent to the adambulacrals. Some plates carry two, and others only one, and are oriented either perpendicularly or obliquely in relation to the ambulacral furrow.

II. Gallery Collection—

(i) One large specimen, dry-preserved. The tubercles are very large, black and prominent. The dorsal surface is dark reddish purple, with scattered spots and tubercles. The reticulated, raised net work of ridges on the back of the disk and rays are prominent. The row of short, thick, spine-like tubercles along the ventral marginal plates of the arms are very distinct.

This is an exceptionally large specimen of this species, but the exact locality is not recorded. Presumably, it has been collected from Mandapam or Pamban.

Measurements : R = 194 mm.

r = 72 mm.

Overall diameter from tip of one arm to the tip of the opposite arm : Over one foot.

(ii) Medium-sized specimen, wet-preserved.

The specimen is uniformly dark brown above, paler brown below. The row of tubercles along the back of each arm is very prominent, consisting of blunt, conical or rounded tubercles. The tips of the arms are slightly turned upwards. The raised, ridge-like areas on the dorsal surface are very prominent and form a close net-work enclosing depressed, pit-like, flattened areas in the meshes of the network. The ventral marginal plates bear a row of conical, fairly sharp spines. The dorsal marginal plates are oblong, almost oval or triangular in shape, being narrowed above, and with their apices pointing away from the ventral surface.

The exact locality of the specimen is not recorded, but it is probably from Pamban.

Measurements : R = 122 mm.

r = 46 mm.

Overall diameter from tip of one arm to the tip of the opposite arm : 225 mm.

Genus *Oreaster* Muller & Troschel.

The body is either rather flat or in the form of a heavily elevated pyramid. The arms are short ($R = 1.7-2.3 r$). The apical plates as well as most of the carinal plates are padded or tubercular, and are of the same size, with one or many short, naked spines; likewise most of the upper and lower marginal plates, central plates and dorsal plates of the disk and the arms. In the centre of the disk is a single big spine, from which the rows of radial plates radiate. The bigger dorsal plates are connected by reticularia. Large, poriferous areas are present in all the corners of the plates on the dorsal side up to the upper marginal plates, spread over the surface of the dorsal plates and fuse frequently. Between the ventro-lateral plates are only a very few odd additional plates, which hardly disturb the regular arrangement of the ventral plates. The whole dorsal side and the marginal plates are covered with a layer of fine granules, which, on the ventral side becomes considerably coarser and bigger. All the ventral plates are with one or more robust spines or a wart (tubercle) in the centre.

Alveoli for the pedicellariae are, as a rule, missing in all the skeletal plates (except in *O. clavatus*, in which they are present on some adambulacral plates). The pedicellariae of the poriferous areas and the ventro-lateral areas possess each one of them a cup-shaped small basal piece, which does not have any tubercle. Two rows of ambulacral spines are present, the inner with three to six thin spines and the outer with one big thick spine.

The species of this genus occur mostly in the Indo-Pacific Region but two species occur in the Atlantic, namely, *Oreaster reticulatus* on the American Coasts and *O. clavatus* on the African Coasts.

In the Madras Museum collection, this genus is represented by a single species, *Oreaster thurstoni* (the other two species in the Madras Museum collection formerly referred to this genus as *Oreaster hedemanni* and *Oreaster lincki* having been subsequently transferred to the genera *Pentaceraster* and *Protoreaster* respectively and designated as *Pentaceraster multifarinus* and *Protoreaster lincki* respectively, as mentioned earlier).

The species *Oreaster thurstoni* is represented in the Museum collection by a specimen collected from Pamban, in the Gulf of Manaar.

Oreaster thurstoni Bell.

FIGURE 73.

Oreaster thurstoni, Bell, F.J., "Report on a Collection of Echinoderms made at Tuticorin", Madras, by Mr. Edgar Thurston, C.M.Z.S., Superintendent, Government Central Museum, Madras", Proc. Zool. Soc. London, 1888, pp. 383-389.

Oreaster thurstoni, Döderlein, Siboga-Expeditie, Oreasterinae, XLVI, 1936, p. 310.

This is a typical triplacanthid form, with the spines, except the five apicals, as a rule, poorly developed. The proportions of the larger radius to the inter-radius is as follows: $R = 2.7 r$.

The disk is moderately elevated; the lophial spines are only just indicated; a spinuous tubercle is present both on the supero- and infero-marginal plates; very rarely, more than one tubercle is present on each such plate. There are no spines on the ventral plates.

The arms are rather short, wide at their base; the marginals are about twenty in number, both above and below. Angles are formed between the superb-marginals into which the pores extend. The spinuous tubercles are very slightly developed and show no indication of becoming spines.

The adambulacral spinulation is triplacanthid (i.e., the spines are disposed in three rows). The spines in the innermost row are eight in number, diverging very gracefully, not very slender. In the middle and outer rows there are two or three spines in each cluster, and these are, as usual, much stouter; but the middle row is much more prominent than the outer. The granulation of the lower surface tends to take on a regular pattern, owing to the aggregation of granules into tufts, in the centre of which is a spiniform tubercle. There are numerous, sessile, bivalved pedicellariae. The pore areas of the dorsal surface are very distinctly marked on and near the disk, but are rather irregular near the sides of the arms. There is no central apical spine. The five spines which end the lophial line are large and prominent and have a marked tendency to double. The other spines of the lophial line are very inconspicuous. Along either side of that line there runs a row of small tubercles; outside these, there is another row which does not extend beyond the disk; the tubercles of these rows are quite small and inconspicuous. The madreporic tubercle is large, situated just outside the apical region, and irregularly quadrate. The colour is creamy yellow. In the largest specimen from Tuticorin, reported by Bell (*loc. cit.*), the measurements are cited as follows:

R = 130 mm.

r = 47 mm.

Of the five specimens collected from Tuticorin, which Prof. Bell had referred to this species, three are reported to possess the typical characters just enumerated. The other two specimens are said to differ to a somewhat remarkable extent from what appears to be the more typical form of the species. In one of these specimens the apical spines are reported to be much less prominent than in the typical forms, while the tubercles on either side are said to be much more distinctly spinose, and many of the inferomarginal plates are reported to bear several spinuous tubercles in a tuft. In the other specimen, the apical spines are described as being large, while the tubercles on either side are said to become quite prominent, the whole appearance of the specimen being thereby quite altered and looking quite different from the typical form.

These differences are only individual variations in one and the same species, and do not justify their separation into distinct species.

Specimens in the collection.—One dry-preserved specimen, exhibited in the Gallery. Locality: Pamban in the Gulf of Mannar.

The specimen is a very large one, with numerous large, raised, blunt, conical tubercles, scattered more or less uniformly throughout the dorsal surface. However, five specially large tubercles at the centre of the disk form a pentagon and from each of these a row of specially large tubercles radiate along the middle of each arm. The disk is large and the arms are relatively shorter, broader and more massive and broad-based than in the preceding species (*Pentaceraster multispinus*). The tubercles are connected by a network of prominent, raised ridges, the meshes of which form spaces which are regularly triangular on the disk and proximal portions of the arms, but irregular over the middle and distal portions of the arms. These intervening surfaces present a coarsely pitted or granular appearance. The tubercles on the dorsal marginal plates are small, short and bluntly conical. The ventral marginal plates are almost smooth and do not bear spines. At most they bear small, blunt tubercles. The specimen is uniformly dark brown above, and paler brown below. The tips of the arms are broad and blunt and slightly turned upwards. The ambulacral grooves are narrow and the ventral surface is concave.

Measurements: R = 144 mm.

r = 76 mm.

Overall diameter from tip of one arm to the tip of the opposite arm: 267 mm.

Genus *Protoreaster* Döderlein.

The body is more or less raised towards the centre of the disk. The arms are of moderate length ($R = 2-3 r$). A number of carinal plates are enlarged, padded and knobby or conical, with or without a naked tip. When they are conical and enlarged they are regarded as spines. Apical spines are always present. They are bigger than the others. All the ventral marginal plates and the dorsal ones in the arm angles (inter-radii) are always without spines. The dorsal plates are either without reticulria or only with solitary reticulria. Large pore fields are present in all the angles of the plates on the dorsal side up to the upper marginal plates, and continued over the margin of the plates. In between the ventro-lateral plates there are more or less numerous small and big supra-ventrals which, in bigger specimens disrupt the orderly arrangement of the main plates. The entire surface is covered with granules, which, on the bigger plates, especially on the carinal and marginal plates and the ventro-lateral plates form small, polygonal plates bearing a smooth surface, and which, on the ventral surface is never knobby or spiny. The pedicellariae on most of the adambulacral plates and on the ventro-lateral plates of the first row and on other skeletal plates have alveoli. There are always only two rows of ambulacral spines, the inner row being made up of six to ten thin ones, and the outer row being made up of two to three thicker spines.

This genus is widely distributed in the tropical Indo-Pacific Regions, but absent in the areas around Sandwich Islands and on the Coasts of America.

The genus *Protoreaster* is sharply demarcated from *Pentacaster* by the complete absence of the inner reticulria and the structure of the outer granular layer, which in places, is made up of bigger and smaller flat plates, instead of being composed of fine, rounded granules, and in never being uneven or rough or spiny on the ventrolateral area.

A single species, *Protoreaster lincki*, which is a characteristic bright reddish form with numerous stout, longish spines on the dorsal side, is represented in the Museum collection by two specimens collected from the Tuticorin Coast.

Protoreaster lincki (de Blainville).

FIGURES 74, 75 and 76.

Pentaceros gibbus, var. *muricatus*, Linck, 1733, De Stellis, marinis liber singularis, p. 23, pl. VII, fig. 8.

Asterias Lincki, de Blainville, Manuel d'Actinologie, 1834, p. 219.

Pentaceros muricatus, Gray, Annals and Magazine of Natural History, VI, 1840, p. 277.

Oreaster muricatus, Dujardin et Hupe Echinod, 1862, p. 383.

Oreaster Linckii, Lutken Videnskab, Meddel., 1846, p. 156, Madagascar, Zanzibar.

Oreaster reinhardtii, Lutken, Videnskab, Meddel., 1864, p. 159, Nikobaren.

Oreaster muricatus, von Martens, p.p. Arch. f. Nat., 1866, pp. 57-88; 133-180, Mozambique.

Oreaster muricatus, Perrier, Pedicell., 1869, p. 74, pl. ii, fig. 3a-b.

Pentaceros muricatus, Perrier, Arch. Zool. Exper., 1876, p. 55 (239), Zanzibar, Seychelles, Ceylon.

Pentaceros muricatus, Viguier, Squal. d. Stell., 1879, p. 197, pl. xi fig. 4-6, pl. xii fig. 8-11.

Oreaster Lincki, Bell, F. J., "On the species of *Oreaster*" Proc. Zool., Soc. London, 1884, p. 72, Mauritius Timor, Mozambique.

Oreaster reinhardti, Bell, 1884, *Ibid.*, p. 74.

Oreaster Lincki, Bell, Proc. Soc. London, 1888, p. 384, Tuticorin—Madras.

Pentaceros Lincki, Brown, Proc. Roy. Soc. Edinburgh, XVIII, 1910, p. 32, Mergui Archipelago, 7—42 m.

Oreaster reinhardti, Koehler, Shallow water Asteroidea collected by the Royal Indian Marine Survey Ship, "Investigator" Indian Museum, Calcutta, 1910, p. 101, pl. xii, figs. 2-3.

Oreaster Lincki, Döderlein, Zool. Jahrb. Syst. Bd. 40, 1916, p. 423, fig. 1.

Oreaster modestus, Goto, Japanese Asteroidea, 1914, p. 444, pl. xv, figs. 228 to 236 (Okinawa).

Protoreaster Lincki, Döderlein, Siboga-Expedition, Oreasterinae, XLVI, 1936, p. 328; pl. xxii, fig. 6; pl. xxiii, figs. 1-7; pl. xxviii fig. 12.

The disk is moderately high; the arms are moderately wide, and not at all acutely pointed. The lophial spines are well developed, the apical spines being very prominent. **A spine or two are sometime developed within the apical region.**

About 18 marginal plates are present. The superomarginals alone form the sides of the arms, and are alone provided with spines; these are confined to the distal end, and very considerably; from one to four may be developed, and in some specimens they are twice as long as they are in others.

The adambulacral spinulation is diplacanthid (i.e., disposed in two rows). In the inner row, eight poorly developed spines are present, and in the outer, two which are **much stouter** for each plate. The tips of the latter are often marked by several shallow grooves. Often, a forcipiform pedicellaria is developed between each inner group of adambulacral spines.

The separate ventral ossicles can hardly, if at all, be made out under the extremely coarse granulation by which they are covered; the separate granules vary considerably in size, and a few valvular pedicellariae are scattered among them. The granules on the marginal plates are hardly less coarse. The dorsal surface is rendered markedly reticulate by the great size and close approximation of the poriferous areas, two of which pass along each side of every arm. In the middle of the arm, the second of these areas **may be equal in length to about half the whole height of the arm**; sometimes, the connecting processes of the ossicles become very delicate, when the whole side of the arm appears to form huge, poriferous areas.

Spines are very irregularly developed at the angle of the areas. Sometimes they are distributed so regularly that there is almost a regular row of spines running on either side of the lophial series; in other cases, they are completely absent. Sometimes the spines of the lophial ridge itself may be absent, but they are ordinarily well developed, as are also the apical spines and the spines that stand below them on the sloping sides of the disk. The granulation on the dorsal spines and ossicles is very coarse and extends quite to the tips of the spines. The madreporic plate is rather small and not conspicuous.

The colour of the specimens (when dry) is reddish on the lower surface. The upper surface is also reddish where the granules are developed, with grey, poriferous areas. In some cases, the dried specimens are almost white, but this may be due to bleaching and the mode of drying.

Bell, F.J., (loc. cit.), examined a series of five specimens which were collected at the same time and place (between tide marks, at Mozambique in May, 1882) by Dr. Coppinger, "H.M.S. Alert", and the above original description is based more or less on these specimens from Mozambique examined by him. but they are typical of the species.

The variations are very marked and are so frequent and so numerous in this species that it seems impossible to establish and definite "varieties". The marginal and ventral plates with their coarse granulation, are sufficiently strong and rigid to ensure the necessary protection for the starfish. The spines are additional defensive structures that are not constantly needed and are developed more in accordance with the prevailing conditions of the individual environment that to meet any general requirements of the species. They are structures which have begun to disappear and their importance to, and necessity for, the starfish may be assessed by the extent to which they vary in number and size on the different arms of one and the same individual.

The species stands midway between *O. alveolatus*, in which the infero-marginal spines are also developed, and *O. nodosus*, in which there are no marginal spines at all. This species has been recorded from the Indian Ocean, and specifically from Mauritius, Timor and Mozambique. On the Indian Coast, it has been recorded from Tuticorin.

Specimens in the Collection: (1) One specimen, dry-preserved, but retaining fairly well, the original reddish colour. Locality: Tuticorin.

The specimen is deep reddish, with very strong, thick, long blunt spines all over the back of the arms and disk. The spines are rather irregularly arranged, and are crowded over the back of the disk, but there appears to be a fairly regular median row of spines along the back of each arm. Near the tip of the arm there are a few strong, lateral spines also on the back of the arm. The dorsal and ventral marginal plates are large, prominent and more or less squarish or oblong (rectangular). The spines on the back of the disk are connected by raised ridges enclosing large, triangular, depressed areas, the surface of which is finely granular. The arms are thick, and more or less sharply demarcated from the disk with blunt, broadly rounded tips. The arms maintain a more or less uniform thickness throughout, and do not taper appreciably towards their tips.

Measurements: $R = 108$ mm.

$r = 61$ mm.

Overall diameter from tip of

one arm tip of opposite arm: 182 mm.

Thickness of arm at the base: 32 mm.

Thickness of the arm near the tip: 27 mm.

(2) There is also a similar specimen of almost exactly the same dimensions, wet-preserved (in alcohol) and exhibited in the Gallery, but the colour is completely faded into a uniform white. Locality: Tuticorin.

(3) One dry-preserved specimen, collected recently (in 1969) from Appa Island, Kilakarai, in Ramanathapuram District. In the living condition, the entire specimen was reported to be bright red in colour, but after dry-preservation, only the strong spines and the ridges on the dorsal side and the entire ventral surface retain their reddish colour, the meshes of the network of ridges and the rest of the surface of the arms on the dorsal side being of a full ochraceous brown colour. These portions (other than the spines and ridges) also present a pitted or porous appearance. The ambulacral grooves on the ventral side are narrow and yellowish at least towards the centre.

The spines on the dorsal surface of the arms are blunt, thick and conical and are disposed in three rows on the upper surface of the arms, those of the central row being

the largest and most numerous. There is an occasional spine near the edge of the arms. The tips of the arms are blunt and slightly up-turned. The ventral surface presents a coarse and closely tuberculated appearance.

Measurements : R = 120 mm.

r = 52 mm.

Overall diameter from tip of

one arm to tip of opposite arm : 214 mm.

Genus *Asterodiscus* Gray.

The body is pentagonal, coriaceous, depressed and covered with numerous, close-set, flat-topped, unequal, small tubercles. The back is convex. The dorsal wart is roundish, sub-central. The arms are short, rounded, with a pair of large, convex, kidney-shaped ossicula on each side of the tip of the arm above. The margin is simple, rounded and concave beneath. The ambulacra bear a series of short, linear spines, placed in groups of four or five, each group on a separate ossiculum, and with two series of larger, blunt, club-shaped spines on the outside of the ambulacral spines. The young specimens have indistinct inferior marginal ossicula.

This genus is closely related to the genus *Culcita*, but is well marked and may be readily distinguished from all other forms of this family. The character of its abactinal tegumentary structure is distinctive and the pair of large marginal plates at the extremity of the arms, distinguish it generically from the other members of the family.

Only a single species, *Asterodiscus elegans* is represented in the Museum Collection (and this is perhaps the only species of this genus known at present).

Asterodiscus elegans Gray.

FIGURE 77.

Asterodiscus elegans, Gray, Proc. Zool. Soc. London, 1847, Part XV, p. 75.

Asterodiscus elegans, Gray, Annals and Magazine of Natural History, XX, 1847, p. 196.

Asterodiscus elegans, Gray, Synopsis of the Species of Starfishes in the British Museum (Natural History), London, 1866, p. 5, pl. xii, figs. 1 and 2.

Asterodiscus elegans, Sladen, Asteroidea, Challenger Reports, Zoology, XXX, 1889, pp. 353-354.

Asterodiscus elegans, Fisher, "Starfishes of the Philippine Seas" Bull. United States National Museum, 100, Vol. 3, 1919, p. 355, pl. 97, fig. pl. 11, fig. 2.

The body is pale brown, when dry, the tubercles of the back are unequal, the larger ones being truncated, and those nearest the mouth on the underside being larger, club-shaped and rather crowded.

The number of the tubercles on the back varies with different specimens. Sladen (*loc. cit.*), states that the specimens collected by the Challenger Expedition have more numerous and prominent tubercles on the abactinal area than Gray's figure represents, and the median radial line is said to be not so distinct as in Gray's figure.

The adambulacral armature consists of: (1) a furrow series of five spines (the aboral one being small and often concealed) and (2;) on the actual surface of the plate a transverse series of three robust, papiliform spines on the inner half of the arm and of two on the outer half (the outermost often with one small, irregular, prismatic granule on each side).

A pedicellaria with two elongate jaws often stands on the adoral side of the first or second of the spines on the actinal surface of the plate, or opposite their interspace, on the middle or outer third of the furrow. Numerous pedicellariae with elongate jaws, often curiously curved, are present on the actinal intermediate plates. The actinal area is very knobby, with triangular, subprismatic granules between the knobs; the usual arrangement appears to be one larger-sized knob to each plate, sometimes accompanied by smaller ones, surrounded by irregular, pinched out granules.

Fisher (*loc. cit.*), commenting on the Philippine specimens of this species reports that the specimens are generally more stellate than Gray's figure seems to represent.

There are numerous abactinal tubercles, and these are of a low, blunt, conical form. A fairly regular carinal series of 11 tubercles is present; and alternating with them on either side is a less regular adradial series, with the beginning of a second series near the centre of the disk. These primary tubercles are surrounded at the base by a ring of convex granules, but the smaller, unequal, slightly spaced secondary tubercles which cover the rest of the abctinal surface are almost always without the granules at the base, unless the tubercle is nearly as large as the primary ones. Nearly all the larger tubercles have at the base a pedicellaria with two slender, curved jaws nearly as long as the tubercle; these are present also beside many of the smaller tubercles.

The supero-marginal plates are two in number (omitting the large distal plates) and are relatively widely separated from the infero-marginals, being actually abactinal in position, and the outer is at the proximal third of the ray. They are covered by four or five tubercles (one larger than the rest) and a circle of tumid granules.

The actinal intermediate plates bear five to ten very coarse, unequal, convex or tubercular granules, one of which is enlarged into a hemispherical or low, accorn-shaped tubercle, one or two of the granules being only slightly smaller. These tubercles are more prominent on the outer half of the ray, and near the mouth plates, being smaller inter-radially. Many of the plates bear a curved, slender, two-jawed pedicellaria.

There are four furrow spines, slightly compressed, round-tipped, the adoral slightly shorter than the other three. The subambulacral spines are two in number, heavy, round-tipped, in a transverse series, the outer the shorter. The margin of the plate is provided with a series of pinched granules. Marginal mouth spines are eight in number, and the suboral spines usually three in a series parallel to the furrow.

Gray states that the type locality of this species is unknown, but Perrier (*Revision de la Collection de Stellerides du Museum d'histoire naturelle de Paris*, 1875, p. 256), records the type as from North-East China.

The range of distribution of this species is Eastern Archipelago and the Indo-Pacific Region.

Fisher (*loc. cit.*), cites the distribution of this species as Phillippines Island and North East China (?), but since it has been recorded from Tuticorin in the Madras Museum collection, its distribution probably extends westwards to the East Coast of India.

Specimens in the Collection: One dry-preserved specimen, exhibited in the Gallery. Locality: Tuticorin.

The body is roughly in the form of a pentagonal disk, the arms being totally absent and indicated only by the broadly rounded, obtuse, angular corners of the pentagonal disk. The corners indicating the arms, each bears a pair of large, convex, kidney-shaped ossicula (plates) on each side of the tip above. These angular corners represent the tips of the reduced and obsolete arms.

The back is convex and covered throughout with closely crowded, blunt, rounded, unequally developed tubercles. The larger ones are rather cylindrical and truncated. Those nearest the mouth on the underside are larger and club-shaped, rather crowded. The specimen is deep earthy or ochraceous brown.

The species being almost in the form of a pentagonal disk, without apparent presence of any distinct arms, the radius in this species is almost equal to the inter-radius.

Measurements : $R = 70$ mm.

$r = 65$ mm.

Overall diameter from
one angular corner to the
opposite one) : 133 mm.

Family LINCKIIDAE
(= OPHIDIASTERIDAE)

This family includes sea stars which are characterized by a small disk, long, flexible, cylindrical arms, reduced and conspicuous marginal plates, and mostly a smooth surface, although some species are warty. The skeleton consists of small, rounded or squarish ossicles or skeletal plates, closely packed to form a mosaic and usually covered with granules.

The species of this family typically inhabit shallow waters in the tropical and sub-tropical zones.

Two genera of this family (according to the earlier classification), are represented in the Museum Collection, (each by a single species), namely, *Linckia* and *Metrodora*. but the genus *Metrodora* has since been separated into a distinct family, the *Metrodiridae*.

In *Metrodora* the arms are slender with larger, single pores and small, scattered spines on the back. In *Linckia*, on the other hand, the arms are relatively stouter, although elongate, cylindrical or trigonal, and tapering towards the tip and the pores are usually disposed in groups or in one or two continuous bands on each side of the arms. Further, in *Linckia*, the papulae are limited to the aboral surface where they occur in rounded groups, irregularly disposed.

Genus *Linckia* Gray.

The arms are five in number, elongate, rather thick, either cylindrical or trigonal, or occasionally rather depressed and flattened. The surface of the body is often covered with a coarse granulation. The pores are disposed in groups or in one or two continuous bands on the arms. The papulae are confined to the aboral surface where they occur in rounded groups, irregularly disposed. There is a series of spines near the ambulacra on the ventral surface of the arms and these are nearly of the same size as the ambulacral spines. The members of this genus are well known for their ability of casting off their arms and regenerating them completely.

A single species, *Linckia laevigata* is represented in the Museum collection.

Linckia laevigata (Linnaeus).

FIGURE 78.

Asterias laevigata (pars), Linné, Systema Nature, ed. xii, 1858 p. 1100.

Pentadactylosaster miliaris, Linck, De Stellis marinis, 1733, p. 34, tab. 21, No. 47.

Linckia typus, Nardo, De Asteriis, Oken's Isis, p. 717.

Ophidiaster laevigata, Muller and Troschel, Monatsber d.k. preuss. Akad. d. Wiss., Berlin, April, p. 103. 1840,

Linckia Brownii, Gray, Annals and Magazine of Natural History, VI, 1840, p. 285.

Linckia crassa, Gray, Annals and Magazine of Natural History, VI 1840, p. 284.

Linckia Typus, Gray, Annals and Magazine of Natural History, VI 1840, p. 284.

Ophidiaster miliaris, Muller and Troschel, System der Asteriden, 1842, p. 30.

Ophidiaster clathrata, Grube, Jahr. Gessellsch. Vaterl. Cultur, 1864, p. 51.

Linckia miliaris, v. Martens, Archiv f. Naturgesch. Jahrg., XXXII, 1866, Bd. i, *Linckia typus*, p. 64. Gray, Synopsis of the Species of Starfish in the British Museum, (Natural History), 1866, p. 13.

Linckia laevigata, Lutken, Videnskab, Meddel, naturh. Foren. i, Kjobenhaven, 1871, pp. 265 and 267.

Linckia miliaris, Sladen, Asteroidea, Challenger Reports Zoology, XXX, 1889, pp. 353-354.

Linckia miliaris, Koehler, R. Shallow Water Asteroidea collected by the Royal Indian Marine Survey Ship, 'Investigator', Indian Museum, Calcutta, 1910, p. 154.

Linckia laevigata, Fisher, "Starfishes of the Phillippine Seas", Bull. United States National Museum, 100, Vol. 3, 1919, p. 400.

Linckia laevigata, Hyman, The Invertebrates, Vol. IV, Echinodermata, 1955, p. 334.

This Sea Star is Common in the Indo-Pacific Regions and is brilliantly blue during life. Dried specimens are generally brownish or pale yellowish or yellowish brown. The arms are five in number, cylindrical, elongate, rather tapering at the ends. The disk is reduced and the arms are merely seven times as long as the width of the disk. The back and side of the arms are covered with equal-sized tubercles and there are moderate-sized dotted interspaces on the sides. The apical tubercles are moderately developed.

This species presents a great range of variation in the length and proportions of the arms, the nature of the tips of the arms (which are sharp and tapering in some individuals, but blunt and thick in others) and in the size and coarseness of the tubercles, and this accounts for the large number of synonyms for this species, such as *L. crassa*, *L. Brownii*, *L. millaris* and *L. typus*.

The ratio of the radius of the disk to the radius of the arm (r:R) is as 1:6. The ends of the arms are rather stumpy and rounded. The arms are about five times as long as broad. The groove papillae are very small, cylindrical and arranged in two rows; the ones in the outer row are seldom not longer than the ones in the inner row. On the oral side, near the groove papillae are 3-5 rows of smaller plates, which are half as large as the plates on the back. On the outer side of these plates, on the sides of the arms are two longitudinal rows of bigger plates. The plates are irregular on the back. The granulation is fine and uniform all over. The pore field on the back are as large as the plates. There are about twelve pores in each field.

Muller and Troschel (*loc. cit.*), while describing the species *Ophidiaster miliaris* which is a synonym for *L. laevigata*, report that the colour of this is dirty yellowish or bluish grey in the dry condition. Originally, the specimens with longer arms which were yellowish were designated as *Linckia typus*, and those with shorter arms which were bluish, as *Linckia brownii*, but as these only proved to be individual variations of one and the same species, both these names are regarded as synonyms of *Linckia laevigata*.

This species attains a large size, reaching an overall diameter of one foot from tip of one arm to the tip of the opposite arm. The species is common and widely distributed in the Indian Ocean and has been recorded by Sladen (*loc. cit.*), in the Challenger Reports, from Kandavu, Fiji Islands (on the reefs), Zebu, Philippine Islands (on the reefs). Koehler (*loc. cit.*), has recorded it from the Andaman Islands. Muller and Troschel (*loc. cit.*), have recorded that specimens of this species are represented in the Berlin Museum and in the Museums of Leyden and Paris.

Fisher (*loc. cit.*), in his Paper on the Starfishes of the Philippine Seas, records twenty-four specimens of this species as having been collected from various localities in the Philippine Seas, and cites the distribution of this species as follows:

"Red Sea, Mozambique, Mauritius, Zanzibar, Persian Gulf, Madras, Andaman Islands, Flores, Timor, Celebes, Batjan, Philippines, Amboina, New Guinea, New Caledonia, Guam, Carolina, Fiji, Samoan and Hawaiian Islands".

Specimens in the collection.—One large, dry-preserved specimen exhibited in the Gallery. Locality: Tuticorin.

The specimen is very large, more or less uniformly brownish, with long, slender, almost cylindrical arms radiating from the greatly reduced and relatively small disk. The arms are almost uniformly thick and only taper slightly towards their tip. The tips of the arms are blunt. The aboral side of the entire starfish is covered with closely crowded, small, rounded tubercles. The sides of the arms bear three or four rows of raised, ridge-like plates separated by oblong, dotted, depressed areas. The apical tubercles is small, but distinct and convexly rounded. The abactinal and marginal plates are distinctly granulose and not bearing spines; this is a characteristic feature of the species of the family Linckiidae.

Measurements: R = 216 mm.

r = 33 mm.

Overall tip to tip diameter (from tip of one arm to tip of opposite arm): 406 mm.

Family METRODIRIDAE.

The whole skeleton is overlaid by a rather thin skin partially obscuring the outlines of the plates. The rays are rather slender. The abactinal plates are tessellate, partly imbricated, with small spines. The marginal plates are large, forming a rather vertical side wall of the ray, there being one or more series of intermarginal plates on the proximal part of the ray. The actinal intermediate plates are reduced to one, between mouth plates and infero-marginals; the papulae are isolated, strictly abactinal. The podia are with sucking disks devoid of calcareous deposits. The ampullae are single. The interbranchial septa are rudimentary, practically absent.

The genus *Metrodira* was formerly placed in the family Linckiidae by Sladen, and other authors had followed this lead. But subsequently Fisher established the separate family Metrodiridae for the reception of this genus owing to certain distinct diagnostic characters, and hence the genus is included in the family Metrodiridae in the present account.

Genus *Metrodira* Gray.

This genus resembles *Linckia* in many respects, but the arms are thinner and relatively more slender and more or less pointed towards their tips. The surface is slightly granular. The arms are slender, with large, single pores and small, scattered spines on the back. On the sides of the arms, however, the surface is smooth and formed of regular flat ossiculae.

A single species, *Metrodora subulata*, which is the type species of the genus *Metrodora*, is represented in the Museum collection. It is the commonest and best known species of the genus.

***Metrodora subulata* Gray.**

FIGURE 79.

- Metrodora subulata*, Gray, Annals and Magazine of Natural History, VI, 1840, p. 282.
- Scytaster subulatus*, Muller and Troschel, System der Asteriden, 1842, p. 36.
- Metrodora subulata*, Gray, Synopsis of the species of Starfish in the British Museum (Natural History), 1866, p. 12.
- Metrodora subulata*, Perrier, Revision de la Collection des Stellerides du Museum d'histoire naturelle de Paris, Arch. Zool. Exp. (1), Vol. IV and V, 1875-1876, p. 180.
- Metrodora subulata*, Viguiier, C., Anatomie Comparee du squelette des Stellerides., Arch. Zool. Exp. (1), Vol. VII, 1879, p. 170.
- Metrodora subulata*, Sladen, Asteroidea, Challenger Reports, Zoology, XXX, 1889, p. 416.
- Metrodora subulata*, Bell F.J., "On the Echinoderms collected during the Voyage of H.M.S. PINGUIN", Proc. Zool. Soc. London, 1894, p. 394.
- Metrodora subulata*, Farquhar, H., "On the Echinoderm Fauna of New Zealand", Proc. Linn. Soc. New South Wales, 1898, Vol. XII, p. 312.
- Scaphaster Humberti*, de Loriol, "Notes pour servir a l'etude des Echinodermes", VII, Mem. Soc. Phys. et Hist. Nat. Geneve, Vol. XXXIII, 1899, p.27, pl. iii, fig. 1.
- Metrodora subulata*, Koehler, Asterias et Ophiures des iles Aroe at Kei, im Dr. H. Merton, Ergebnisse einer Zoologischen Forschungsreise in dem Sud Ostlichen Molukken Abhand. Senckenb. Gesells. Bd. XXIII, 1919, pl. xv, figs. 3, pl. xvii, figs. 3, 4 & 5.
- Metrodora subulata*, Koehler, Shallow Water Asteroidea Collected by the Royal Indian Marine Survey Ship "Investigator", Indian Museum, Calcutta, 1910, p. 172; pl. iv, fig. 1 and 2; pl. xviii, fig. 9.
- Scaphaster humberti*, Loriol, P. de, Notes pour servir a l'etude des Echinodermes, Mem. Soc. Phys et hist natur. Geneve, XXXIII, pt. 2, No. 1, p. 27, pl. iii, fig. 1.
- Metrodora subulata*, Fisher, "Starfishes of the Philippine Seas", Bull. United States National Museum, 100, Vol. 3, 1919. p. 406.

There are five arms. The relation of the disc radius to the arm radius is as 1:8. The arms are very thin, (narrow) and long, nearly linear and pointed at the tip. On every plate on the oral side is one row of four small spines which are arranged across the arms. Then follow a row of nearly granulated plates on the oral side, so that the dorsal ones alternate with the ventral ones. The back of the disk and the arms are covered with plates which are nearly arranged like the tiles of a roof, these being smaller than the lateral plates. Every one of these plates has one or at times two small spines. The colour is yellowish.

Koehler (*loc. cit.*), reporting on the collection of Asteroidea made by the R.I.M.S. ship "Investigator", states that the dimensions of the specimens are variable. In the largest specimens reported by him the $R = 35$ mm. In the larger number of specimens examined by him, the spines on the dorsal plates are rather numerous; in some specimens, the spines are stated to be very much less numerous. There is considerable variation also in the thickness and proportionate length of the arms. Generally, the arms are comparatively shorter and thicker, the dorsal surface is more convex and the dorsal marginal plates are lacking on the sides of the arms, while in some specimens, the arms are more flattened, narrower and longer and the dorsal marginal plates encroach further on the dorsal surface of the arms. The extremity of the arms is generally pointed. The spines are very much less numerous on the disk than on the arms in some specimens the arms are very narrow and their dorsal surface is very much flattened. In others, the arms are wider and thicker, convex and the plates carry numerous spines.

Koehler suggests that at first sight these two forms appear so distinct that one may be tempted to regard them as two distinct species, or at least as two distinct varieties; the specimens with more numerous spines might appear distinct enough to be separated as a distinct variety which may deserve to be called rightly *spinosa*. But he states that such a separation is not justified, since in the series of specimens examined by him in the Indian Museum collection, he is reported to have found forms intermediate between the two extreme forms mentioned above. He has observed, in particular, specimens with arms relatively short and thick, armed with numerous spines, but in which the dorsal marginal plates encroach on the dorsal surface as much as in others in which the spines are less abundant and reducing thus the width of the area formed by the dorsal plates of the arms. These forms therefore cannot be referred to the first or to the second type definitely; it is interesting to note that there are such extreme variations in this species.

The affinities of the genus *Metrodira* are rather uncertain. Gray placed it next to *Echinaster*, between the genera *Othilia* and *Rhopia*. Perrier has ranked *Metrodira* next to the genus *Scytaster*, but in the nature of its skeleton, he states that it approaches certain species of *Echinaster*, for example, *Echinaster eridanella*, and it is also stated to approach *Fromia*, in which one observes a granulation more or less serrated and where the spines are completely wanting.

De Loriol (*loc. cit.*), in describing *Metrodira subulata*, under the name of *Scaphaster Humberti* appears equally confused and is rather diffident about classifying the new genus which he had believed to have been able to create. It appeared to him to be related to the *Gymnasterides*, approaching in particular the genus *Asteropsis* in this group.

Koehler himself is certain that the genus *Metrodira* properly belongs to the family of the Linckiades as defined by Perrier. The disposition of the plates with two distinct series of dorsal and ventral marginals recalls the condition which obtains in the majority of the genera of this family and notably in the genus *Fromia*.

There is undoubtedly a close resemblance between the genera *Metrodira* and *Echinaster* and this resemblance is accentuated in the present species, *Metrodira subulata* possessing very well developed spines, but this seems to be only a purely exterior and superficial resemblance, and the structure of the skeleton is quite different in the two genera.

Fischer, (*loc. cit.*), commenting on the Philippine specimens of this species, reports that the Philippine examples are less spiny abactinally. The proximal plates of the inter-marginal series in these specimens are reported to be nearly as large as the adjacent infero-marginals, and there is usually an odd inter-radial inter-marginal plate, but not an odd supero- or infero-marginal. The intermarginals in the Philippine specimens examined by Fisher are said to extend about half the length of the ray.

The type locality of this species is cited as Migupou which Fisher considers might be probably a Philippine locality.

Metrodora subulata has been recorded in Australia, at Migupou and in the Torres Straits. Specimens of *Scaphaster Humberti* (which is a synonym for *Metrodora subulata*) have been collected at Ceylon. The specimens of this species represented in the Indian Museum collection at Calcutta and examined by Koehler are from various localities; some of them are from Ceylon, while others belong to different localities in the Bay of Bengal. The species has a rather wide range of distribution in the Indian and Pacific Oceans. It is also likely to be found in localities other than those which have so far been mentioned by Koehler and earlier authors.

The entire range of distribution of this species is defined as follows: (Fisher, loc. cit.):

Macclesfield Bank: Philippine Islands; Torres Strait; Aru; Amboina; north-west of Australia; north-east Australia; George Sound, New Zealand; Bay of Bengal; Ceylon.

Specimens in Collection.—This is a rather small-sized starfish in which the disk is reduced and the arms are relatively long and slender. The surface is slightly granular. The rays (arms) are elongated, slender and tapering with large pores and small, scattered spines on the back. The spines are small, crowded, scattered on the sides and at the junctions of the slender ossicula. The colour in the fresh condition is yellowish brown, but the colour in the present preserved specimens in the Museum collection is almost faded to a pale whitish brown.

The species is said to be confined to shallow water. In the Challenger Reports, it is stated as having been taken at eight fathoms. The species inhabits coral mud.

Two specimens, both wet-preserved, are represented in the Museum collection.

Locality: Off Ceylon. The arms are slender, with pointed tips, and the colour is stated as having been taken at eight fathoms. The species inhabits coral mud.

Measurements:

(1) Smaller specimen:

Length of the arm: 14 mm.

Diameter of the disk: 8 mm.

Overall width of the specimen: 34 mm.

(2) Larger specimen:

Length of the arm: 21 mm.

Diameter of the disk: 11 mm.

Overall width of the specimen: 41 mm.

ORDER SPINULOSA.

The arms are generally without conspicuous marginal plates, which are generally small. Pedicellariae are rarely present. The arms may be short, broad and blunt, or slender and cylindrical. They are normally five in number, but sometimes, as in the Sun Star, *Solaster*, the arms may be numerous and variable in number, ranging from 1 to 14. The aboral skeleton is imbricated or reticulated with single spines or groups of spines, not infrequently paxilliform. The mouth frame is of the adambulacral type as in the Phanerozonia. The podia are provided with typical suckers and occur in two rows in each ambulacral groove. The ampullae are single or bifurcated. This Order is not sharply distinguishable from the Phanerozonia, but one salient distinguishing feature is that conspicuous marginal plates forming a broad, vertical edge to the arms are usually wanting in the Order Spinulosa.

Representatives of two families belonging to this Order are contained in the Museum collection, namely, the families Asterinidae and Echinasteridae.

In the Asterinidae, the body is often broadly stellate, with a thin margin and the disk is relatively large and the arms short, broad, blunt and merging broadly with the disk at the base.

The Echinasteridae, on the other hand, are characterized by a small disk, and five slender, cylindrical arms, quite sharply demarcated off from the disk.

Family ASTERINIDAE.

The body is often broadly stellate, with a thin margin. The aboral surface is composed of scale-like, imbricated plates carrying groups or tufts of spinelets or granules, and the oral surface is also composed of imbricating plates bearing a tuft or fan of spinelets. The body is discoidal or pyramidal, sharp-edged. The skeleton is formed of flattish, imbricate plates. The dorsal wart is single, rarely double.

Two genera, namely, *Asterina* and *Anseropoda* (of which the formerly used, more familiar name, *Palmipes* is a synonym) are represented in the Museum Collection, the former by two species and the latter by one species.

The genus *Anseropoda* (= *Palmipes*) is distinguished from *Asterina* by the very strongly flattened, extremely thin and almost membranaceous body and by the presence of a median crest along each arm on the aboral surface, while in *Asterina* the body is more convex and rather pyramidal and there is no appreciable median keel or crest along the aboral surface of each arm.

Genus *Asterina* Nardo.

The body is rather pyramidal, 5-rayed. The dorsal side is convex, while the oral side is flat. The ossicula of both the surfaces are furnished with one or more oblique, tapering spines. The margin is sharp-edged; each of the ossicula carries a marginal series of spines. The ambulacral spines are placed in groups of four or five. The main aboral plates are not crescentic, and both surfaces are covered with tufts of small spines.

This well characterized genus has been subjected to comparatively few changes at the hands of systematists. Perrier pointed out that there is no valid reason for discarding the original name of *Asterina* given by Nardo in favour of *Asteriscus* proposed by Muller and Troschel, on the ground that the word in question was employed by Lihuyd and Linck. *Asteriscus* was not used in the sense of a generic name prior to 1840.

In spite of the considerable number of species included in this genus, the amount of structural variation within the limits of the genus which they represent is comparatively small.

The distribution of the genus is almost cosmopolitan, but confined to the tropical and temperate seas.

Two species of the genus, namely, *Asterina cepheus* and *Asterina coronata*, are represented in the Museum collection. Specimens of both these species in the Museum collection are from Krusadai Island and the Pamban area in the Gulf of Manaar. In *Asterina coronata* the arms are proportionately longer and meet in a more distinct angle than in the preceding species (*Asterina cepheus*).

Asterina cepheus (Muller and Troschel).

FIGURES 80 and 81.

Asteriscus cepheus, Muller and Troschel, System der Asteriden, 1842, p. 41.

Asteriscus cepheus, Valenciennes, MS.

Asterina Burtonii (?), Gray, Annals and Magazine of Natural History, VI, 1840, p. 289,

- Asterina Burtonii*, Gray, Synopsis of the Species of Starfish in the British Museum, 1866, p. 16.
- Asterina cepheus*, von Martens, Archiv. f. Naturgesch. Jahrg xxxii, 1866, Bd. i, p. 85.
- Asterina cepheus*, Sladen, Asteroidea, Challenger Reports, Zoology, XXX, 1889, p. 396.
- Asterina cepheus*, Sladen, Journ. Linn. Soc. London, (Zoology), XXI, 1889, p. 330.
- Asterina cephea*, Koehler, R., Shallow Water Asteroidea collected by the Royal Indian Marine Survey Ship, "Investigator", Indian Museum, Calcutta, 1910, p. 128.
- Asterina cepheus*, Lorient, P. de, Catalogue raisonné des Echinodermes recueillies par M.V. de Robillarda l'île de Maurice 2. Stellerides, Mem. Soc. d. Phys. et d'hist. natur. Genève, XXIX, 1885, p. 69, pl. 21, figs. 1-5.
- Asterina cepheus*, von Martens, Ueber ostasiatische Echinodermen, 2 Archiv. f. Naturgesch., 1866, p. 85.
- Asterina cepheus*, Bell, F.J., "Report on the Zoological collections made in the Indo-Pacific Ocean during the Voyage of H.M.S. "Alert", 1881-1882, British Museum, London, 1884, p. 131.
- Asterina cepheus*, Fisher, "Starfishes of the Philippine Seas", Bull. United States National Museum, 100, Vol. 3, 1919, p. 411.
- Asterina cepheus*, Gravely, "Littoral Fauna of Krusadai Island" Bull. Mad. Govt. Mus. (Natural History), I, No. 1, 1927, 169.
- Asterina cephea*, Clark, A. H. "Echinoderms from the Marshall Islands" Proc. United States National Museum, Vol. 102, 1952, p. 289.

The arms are five number and short and obtuse, while the disk is relatively large. The body form is pentagonal, and very similar to that of *Asterina exigua*. The arms are blunt, with a very flat and thin projecting margin. The ratio of the arm to the inter-radius, i.e., R:r is as $2\frac{1}{2}$: 1. The groove papillae are in a single row, six to seven on each plate, arranged very regularly and fan-wise, an arrangement in which the middle spines are very much longer than the lateral ones which are very short. On every plate on the oral side there are 2 to 5 short, pointed, small spines, in the form of a small bunch. The plates of the back are raised in the form of scales, so that the margins project inwards and outwards and on the margins of each plate is found a row of short, small spines. The tentacle pores—11-13 rows—reach up to the proximity of the margin.

Gray (*loc. cit.*) describing *Asterina Burtonii* (which is only a synonym for the present species, *Asterina cepheus*) states the diagnostic features of this species as follows: the arms are elongate, convex, blunt at the end; each of the ossicula of the oral surface bears a central group of three, crowded, mobile, tapering spines; and each of the ossicula of the dorsal surface bears a crowded group of short tubercles.

Sladen (*loc. cit.*, 1889) cites the key characters of this species as follows:—

1. Actinal intermediate plates with two to five spines on each plate.
2. Adambulacral plates with more than three spines on the actinal surface. Abactinal plates almost naked; spinelets simply marginal and inconspicuous.
3. Actinal intermediate plates with two to four short, small, conical spinelets, not united. Adambulacral plates with five to seven spines on the furrow series and four or five on the actinal surface.

Sladen doubts the specific distinctness of this species from *Asterina coronata*. Both *Asterina cepheus* and the next species, *Asterina coronata*, have the upper surface of the disk ornamented in the middle, with a low crown of plates which is not found in the species of the next genus, *Anseropoda*.

Fisher (*loc. cit.*), commenting on the Philippine specimens of this species reports that the largest specimen examined by him was of the size $R = 20$ mm., and $r = 8$ mm., **this being larger than any of the Pamban specimens of this species contained in the Madras Museum collection.**

Fisher (*loc. cit.*), also remarks in this connection that the type of *Asterina burtonii* (which has priority over *cepheus* and which is a synonym for *Asterina cepheus*) has been lost, according to Professor Bell. Fisher states that although the name probably refers to **this species**, in the absence of an authentic specimen, Gray's description is quite insufficient. He suggests, therefore, that it seems better to retain the well known name, *Asterina cepheus*, so long as a reasonable doubt exists as to the identity of *burtonii*.

Bell (*loc. cit.*), follows Prof. Perrier in using Muller and Troschel's specific name (*Asterina cepheus*) on the ground that, though Gray's name, *burtonii*, has the precedence **by two years**, the "type" is not to be found, and the description of Gray (of *burtonii*) is therefore useless for any purposes of identification. As *cepheus* is obviously therefore the **proper name**, Bell prefers to use it without any alterations in its nomenclature.

This species (*Asterina cepheus*) inhabits shallow water. In fact, all the species are confined to the Littoral zone. The nature of the sea bottom where they occur is probably always more or less hard. Specimens of *Asterina cepheus* are usually found among rocks and stones on coral reefs.

Asterina cepheus is a widely distributed species. It is one of the seven or eight species of *Asterina* that occurs in the Indian and Southern Oceans. It also occurs in the Eastern Archipelago.

Gray (*loc. cit.*), has recorded it from the Red Sea (*Asterina Burtonii*, which is a synonym for *Asterina cepheus*). Sladen (*loc. cit.*), has recorded the Challenger Expedition specimen of this species from Samboangan, Philippine Group, at a depth of ten fathoms on the reefs. Koehler (*loc. cit.*), records two specimens of this species in the Indian Museum Collection, one from Karachi and the other from the Nicobars, and Gravely (*loc. cit.*), records a single specimen from Kutikal in the Pamban area of the Gulf of Manaar, but subsequently more specimens of this species have been collected from **Krusadai Island and Pamban area** and these are represented in the Museum Collection.

Fisher (*loc. cit.*), has cited the distribution of this species comprehensively as follows: Red Sea, Indian Ocean (Zanzibar in the South, Nicobar Islands, Ceylon, Mergui, in the North), Java, Philippines, Torres Strait, Australia, New Guinea and New Caledonia.

Bell (*loc. cit.*), records this species from Thursday Island.

Sladen (*loc. cit.*), (1889) reporting on the Asteirodea of the Mergui Archipelago, has recorded *Asterina cepheus* from King Island (Mergui Archipelago; native name; Padaw): February, 1882; and from Sir William Jones Island: 7th December, 1891.

The examples of this species collected in the Mergui Archipelago (Sladen, *loc. cit.*, 1889), are reported to be rather more discoidal than usual, the interbranchial arcs being less incurved than usual; the spination is also much more delicate and cilia-like. Sladen observes that the differences, however, do not appear to him to be sufficient to warrant their recognition by name as a distinct variety; a good series of specimens are essential before they could be ranked as a variety with any degree of certainty.

Specimens in the collection: Several spirit-preserved specimens in the Reference Collection and three dry-preserved specimens in the Gallery series are represented in the Museum collection.

I. Reference Collection.—There are several spirit-preserved specimens of this species in the Reference collection. All of them are small and scarcely exceed a maximum diameter of 30 mm. (including the arms). The arms are short, bluntly rounded at their tips and not sharply demarcated from the disc. The surface (both above and below) is coarsely and regularly granulated. The margins of the inter-radial regions (connecting the species between the successive arms) are thin, flattened and lamina-like.

The specimens are, as a rule, uniformly greyish brown. The ambulacral grooves are narrow, sharply marked and dark brown. At the centre of the disc on the dorsal surface, there is a well marked, small, circular, flattened area, bounded by a corona of raised, ridge-like tubercles.

- (1) Two specimens. Locality: Shingle Island, Gulf of Manaar (1930).

Measurements: (Both are almost identical in size).

$$R = 16 \text{ mm.}$$

$$r = 10 \text{ mm.}$$

Overall diameter (including the arms): 30 mm.

Diameter of the disk alone: 17 mm.

- (2) Three young specimens: Locality: Shingle Island, Gulf of Manaar.

The colour of these specimens is whitish above and slightly darker below. Of these, one is almost in the form of a pentagonal disc—with the arms represented just by the angular points.

Measurements:

- (a) Of the largest of these three young specimens: (pentagonal, disk-like specimen):

$$R = 7 \text{ mm.}$$

$$r = 5 \text{ mm.}$$

Overall diameter (including arms): 16 mm.

- (b) Of another smaller young specimen in this lot:

$$R = 8 \text{ mm.}$$

$$r = 5 \text{ mm.}$$

- (3) One adult specimen, pale whitish brown in colour. Locality: not recorded, probably Krusadai Island, in the Gulf of Manaar.

Measurements: $R = 14 \text{ mm.}$

$$r = 10 \text{ mm.}$$

Overall diameter (including arms): 28 mm.

- (4) One specimen, pale creamy white in colour. Locality: Krusadai Island, September, 1948.

The central flattened circular area on the dorsal surface of the disc is not clear in this specimen. The mouth aperture on the actinal surface is deep, and pentagonal in outline.

Measurements: $R = 14 \text{ mm.}$

$$r = 9 \text{ mm.}$$

Overall diameter (including arms): 26 mm.

- (5) One specimen, pale greyish brown above and dirty pale brown below. Locality: Kilakarai, Ramanathapuram District, February, 1913.

The surface of the body is granular throughout. The central circular area on top of the disk is well defined and bordered by a circlet of raised ridges.

Measurements: $R = 15$ mm.

$r = 9$ mm.

Overall diameter (including arms): 30 mm.

(6) One moderately young specimen, dirty greyish brown in colour. Locality: Kutikal, Gulf of Manaar, 1925.

The disk is rather well raised. The central circular area on the upper side of the disk is distinct and well bounded with raised ridges. The ventral surface is rather concavely depressed.

Measurements: $R = 10$ mm.

$r = 7$ mm.

Overall diameter (including arms): 20 mm.

II. Gallery Collection.—Three dry-preserved specimens are exhibited in the Gallery. Locality: Pamban, Gulf of Manaar.

These specimens are all uniformly yellowish brown in colour. The aboral surface presents a markedly pitted appearance owing to the presence of small, closely and regularly arranged rows of tubercles. The oral surface is also uniformly tuberculated with small, close-set granules. The arms are short, blunt, with broadly rounded tips and not sharply marked off from the disc. Towards the edge, the body is rather flattened and the inter-radial areas of the surface are rather depressed.

Measurements (of the largest specimen):

$R = 24$ mm.

$r = 15$ mm.

Overall tip to tip diameter (including the arms): 44 mm.

The other two specimens are only slightly smaller than this, and in one of them, one of the arms is broken and incomplete towards the tip.

Asterina coronata von Martens.

FIGURE 82.

Asterina coronata, von Martens, Ueber Ostasiatische Echinodermen, 2, Archiv, f. Naturgesch., 1866, pp. 57-88.

Asterina, novae-zealandiae, Goto, "A Descriptive Monograph of Japanese Asteroidea", Journ. Coll. Science, Imperial Univ., Tokyo, XXIX, 1914, art. 1. pp. 647-651.

Asterina cristata, Fisher, "New East Indian Starfishes", Proc. Biol. Soc. Washington, XXIX, 1916, p. 27.

Asterina coronata cristata, Fisher, "Notes on Asteroidea - II", Annals and Magazine of Natural History, ser. 9, Vol. 2, 1918, p. 111.

Asterina coronata cristata, "Starfishes of the Philippine Seas", Bull. United States National Museum, 100, Vol. 111, 1919, p. 411, pl. 115, fig. 3, pl. 131, figs. 4, 4 a.

Asterina coronata, Gravely, Littoral Fauna of Krusadai Island in the Gulf of Manaar, Bull. Madras Govt. Museum, Natural History, I. No. 1, 1927, p. 169.

Asterina coronata, Hayashi, Bull. Bigoeogr. Soc. Japan, VIII, 1938, pp. 197- 222 (notes); p.215.

Asterina coronata fascicularis, Clark, "H.L., "Echinoderms from Australia,, Mem. Mus. Comp. Zool., Harvard, Vol. 55, 1938, pp. 145 - 148. (described and variations mentioned).

Asterina coronata, Clark, A.H., "Echinoderms from the Marshalls Islands", Proceedings of the United States National Museum, Vol. 102, 1952, p. 289, (Brief remarks).

This species is closely related to the preceding species, *Asterina cepheus*. The main difference between *A. coronata* and *A. cepheus* (= *burtonii*) is the development in the former of some more or less enlarged dorsal plates with distinctly coarser spinelets than the other plates. The arms are also longer in *Asterina coronata* and meet in a more distinct angle than in the preceding species.

Asterina coronata has a variable number (30 to 55 to a ray) of the abactinal plates elevated and tubercular in form, and surmounted by 1 to 5 unequal, robust, pointed spines, the largest being four or five times as long as the spinelets of the other plates, and many times greater in diameter. The other abactinal plates are provided with five to ten short, sharp spinelets in spaced out groups situated usually on the adcentral border; these spinelets are tapering, slender, three or four times as long as the width of their base, and in each group are placed with the bases touching, but with the spinelets themselves radiating apart. In the centre of the disk, a poorly defined pentagon of elevated spines is present. At the base of the ray, there are six regular series of papulae on either side of a radial area of irregularly arranged pores, the two areas corresponding to regions of regularly and irregularly arranged plates. The plates of the regular lateral series (of which there are ten at the base of the ray) are arranged in quincunx (five rows) and those of the papular areas are hollowed out or by the group of spinelets. In the radial area, the slight hollow is on the adcentral border. excavated on the mesial border for the papula which is overhung and evidently protected. **The infero-marginal plates have a conspicuous tapered spine surrounded by smaller spinelets.** The actinal intermediate plates bear a group of 2 to 4, mostly 3 basally wedged spinelets. The furrow spines are usually six in number, webbed for about half their length, the three or four median ones being markedly larger than the laterals. The subambulacral spines are usually four in number, the two median ones being much longer than the laterals. Oral spines are five in number, webbed, the two innermost being conspicuously enlarged; the suboral spines are 3 to 5, upright, webbed, two of them being of predominant size. The rays are five in number, rather narrow, longer than usual, and with a rounded extremity.

Fisher (*loc. cit.*) actually considers the typical form of the species described above as a subspecies of *Asterina coronata* namely, *cristata*, since he distinguishes another subspecies, *Asterina coronata eurces*, Fisher, among the Philippine specimens, which differs from the above typical form in having abactinal, spiniform pedicellariae, only twelve to fourteen swollen abactinal plates to a ray, eight furrow spines, eight or nine marginal mouth spines. The Pamban specimens of *Asterina coronata* are of the typical form described above and designated by Fisher as *Asterina coronata cristata*. However, Miss A. M. Clark, M.A., Keeper, Echinoderm Section of the British Museum (Natural History), London, who was consulted in the matter has stated that she is herself doubtful whether it is worth maintaining Fisher's races of *coronata* (as the differences on which he bases the distinction seem trivial and may well be in the nature of individual variations within the species itself). In view of this, the form is described in the present account merely as *Asterina coronata*, without going into the subspecific distinction.

Fisher (*loc. cit.*), reports that the number of protuberences probably varies somewhat with age and local conditions in the subspecies *cristata* which is the typical form of the species *Asterina coronata*.

The type locality is cited as Ponape, Caroline Islands, and the distribution mentioned as Caroline Islands, but actually the distribution of this species appears to be more extensive and extends from Japan in the far east through the Eastern Archipelagoes, Philippines, westward to the coasts of India and even beyond, to the Pacific. A. H. Clark (*loc. cit.*, 1952) records it from Marshall Islands in the Pacific Ocean.

Specimens in the collection.—A single specimen, preserved in alcohol, is represented in the reference collections of this Museum. Locality: Krusadai Island, Gulf of Manaar, 1925.

The specimen has the tips of the arms slightly turned upwards. The colour of the specimen (in alcohol), is dirty greyish brown above and paler brown below.

In this species, the arms are narrower, relatively larger and much better demarcated from the rest of the body than in the preceding species (*A. cepheus*.) The centre of the dorsal surface of the disk is encircled by a raised, circular ridge (corona-like; hence the specific name, *A. coronata*). All these characters are very well seen in the present specimen examined. The dorsal surface has a coarsely pitted appearance, and the ventral surface uniformly granular in appearance. The ambulacral grooves are dark greyish, almost closed, and not widely open as in the specimens of the next species, *Anseropoda sarasini* examined in the Museum collection.

Measurements: R = 18 mm.

r = 8 mm.

Overall tip to tip diameter: 25 mm.

Genus *Anseropoda* (= *Palmipes* Linck).

The body is flat, thin, nearly membranaceous. The margin is radiately striated. The dorsal ossicula bear a radiating tuft, and the oral ones bear a transverse line of many thin, mobile spines; the ambulacral spines are disposed in oblique rounded groups. In this genus, the low crown of plates found on the side of the middle of the disk in *Asterina* is not found.

This genus is characterized by the very broadly pentagonal shape of the body and is remarkable for the almost wafer-like thinness of the body. On the aboral side, there is a median crest along each ray, and both surfaces are provided with tufts of minute spinelets.

A single species, *Anseropoda sarasini* (= *Palmipes sarasini*) is represented in the Museum collection, by a number of specimens collected from Pamban.

Anseropoda sarasini (de Loriol).

FIGURE 83.

Palmipes sarasini, Loriol, p. De, "Notes pour servir a l'etude des Echinodermes, V, Mem. Soc. Phys. et Hist. Nat. Geneve, XXXII, 2me partie, p. 11, pl. 1, fig. 4.

Palmipes sarasini, Koehler, R., "Shallow water Asteroidea, collected by the Royal Indian Marine Survey Ship, "Investigator", Indian Museum, Calcutta, 1910, pp. 127-128; pl. xix, figs. 1 and 9.

Palmipes sarasini Gravely, Littoral Fauna of Krusadai Island (in the Gulf of Manaar), Bull. Madras Govt. Mus. (Natural History Section), I, No 2, 1927, p. 169.

Koehler (*loc. cit.*), has recorded this species from the Andamans and Nicobar Islands and has referred to five specimens of this species from Andaman Islands and one specimen from Nicobar Islands in the collections of the R.I.M.S. Ship "Investigator" in the Indian Museum. The diameter of these specimens is said to range between 35 and 27 mm., but in two specimens among them one of the arms is reported to have been completely atrophied.

The original description of this species was published by P. de Loriol (*loc. cit.*). Normally, in this species, the dorsal plates are very finely granulated and carry, in their central region, a cluster of two to five very small, hyaline (semi-transparent) and cylindrical spines. But Koehler (*loc. cit.*), observes that this is not the condition found in absolutely intact specimens which have not suffered damage. In such specimens the plates of the central region of the disk and projecting parts of the arms carry each one, in their middle, a tuft or bunch consisting of numerous spines, extremely fine and very closely pressed together, which are arranged along an arch, the concavity of which is turned to the side of the corresponding pore. In proportion to the extent to which it is removed from the median line, the arc formed by the spines diminishes in length and is terminated by only a small bundle of a few spines as stated by P. de Loriol. The marginal spines are also generally more numerous and more close-set than is indicated in the original description of this species given by P. de Loriol. Koehler (*loc. cit.*), reports that he had examined one of the types of this species preserved in the Museum of Geneva and found that it had lost a great part of its spines and it is this factor that was responsible for the variation noticed between P. de Loriol's original description and the condition now observed by Koehler in the Indian Museum specimens.

Gravely (*loc. cit.*), has observed that the specimens of this species found at Pamban are larger than those of the two species of *Asterina* taken in this locality (*A. cephea* and *A. coronata*), and that in the genus *Palmipes*, the low crown of plates found in the middle of the upper surface of the disk in *Asterina* is lacking. A number of specimens of *Palmipes sarasinii* (in the living condition) have been collected from Pamban. They are usually found attached firmly to some substrata like rocks and pieces of dead coral by their oral surfaces.

Specimens in the collection.—This species is represented in the Museum collection by several specimens from Pamban and Pamban Bridge in the Reference collection, and by one specimen, also collected from Pamban, in the Gallery collection.

I. Reference Collection.—(1) One specimen: Locality: Pamban, 1922. The specimen is fairly large, dirty greyish brown, with the tips of the arms blunt, broadly rounded and obtuse, slightly upturned. The ambulacral grooves are dark brownish. Both the upper and lower surfaces are uniformly granular appearance. The margin is somewhat thinned out.

Measurements:

$$R = 21 \text{ mm.}$$

$$r = 15 \text{ mm.}$$

Overall diameter from tip of one arm to tip of opposite arm: 40 mm.

(2) Three young specimens, more or less similar in size: Locality: Pamban, 1922. The specimens are dark greyish brown, both above and below. The ambulacral grooves are dark brownish. The surface is uniformly granular both above and below. The margin is somewhat thinned out.

Average measurements:

$$R = 16 \text{ mm.}$$

$$r = 11 \text{ mm.}$$

Overall diameter from tip of one arm to tip of opposite arm: 28 mm.

(3) One specimen: Locality: Pamban Bridge. Colour: reddish in life, but faded to a pale creamy brown in this spirit-preserved specimen. The specimen is partly disintegrated, one of the arms being incomplete. The surface is granular, both above and below. The ambulacral grooves are darker brown.

Measurements:

$R = 15$ mm.

$r = 11$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 30 mm.

(4) One specimen: Locality: Pamban Bridge, 1948. This is the only specimen in the collection that retains to some extent the original reddish colour, although the specimen is preserved in alcohol. The margins are somewhat thinned out. The arms are very obtuse and broadly rounded and blunt. The dorsal surface presents a closely reticulated, pitted appearance, while the lower surface is uniformly granular. Colour: slightly reddish brown tinge, both above and below.

Measurements:

$R = 17$ mm.

$r = 13$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 35 mm.

II. Gallery Collection.—(1) Two wet-preserved specimens exhibited in the Gallery. Locality: Pamban. The specimens are completely bleached and are of a uniformly dirty-white or greyish white colour. The surface presents a granular appearance owing to the presence of small, close-set rounded tubercles. The arms are short, **broadly rounded and not sharply demarcated** from the disk. The ambulacral grooves are dark greyish.

Measurements (of the larger specimen):

$R = 16$ mm.

$r = 12$ mm.

Overall diameter from tip to one arm to tip of opposite arm: 34 mm.

Family ECHINASTERIDAE.

The Echinasteridae are characterized by a small disk and five slender, cylindroid rays. **The skeleton is reticulated** with open meshes and single spines or a few spines at the **nodes**. The species belonging to this family are usually red or orange in colour.

This family is represented in the Museum collection by a single species belonging to the genus *Echinaster*.

Genus *Echinaster* Muller and Troschel.

(=*Othilia* Gray).

The body is star-like, granulated, depressed; the back is rather convex, with a circle of 10-15 conical dorsal warts. The ambulacral spines are small, placed in groups, with a single, continuous row of large, slender spines near them. The spines are very long and covered with a granular skin, and have generally a second articulation about one-third the length from the base. The arms are elongated, conical or cylindrical. An interconnected network of ridges is present in the integument, from which the longer or shorter spines appear, sometimes single and sometimes many and closely crowded together. The skin, between the meshes of the network is **naked**, with many tentacle-pores. The anus is sub-central.

A single species, *Echinaster purpureus*, is represented in the Museum collection. This species is subject to considerable variation and has hence been known by various other synonymous names such as *Echinaster fallax*, *Othilia purpurea* and *Othilia luzonica*.

Fisher, in his paper on the "Starfishes of the Philippine Seas", (Bulletin of the United States National Museum, 100, Vol. 3, 1919, p. 426), commenting on the systematic position of the genus *Echinaster* observes that the genus *Echinaster* Muller and Troschel (April, 1840) is usually understood to include *Othilia* and *Rhopia* Gray (December, 1840). In a key to the Echinasteridae in his paper on the Asteroidea of the North Pacific, etc., (*loc. cit.*, 1911, p. 259), Fisher recognised *Othilia* for those species which have, in addition to abactinal papulae, also intermarginal papulae or both intermarginal and actinal papulae, while the name *Echinaster* by implication was reserved for *Echinaster sepositus* and its allies, in which there are neither intermarginal nor actinal papulae. Hence Fisher describes the species *purpurea* as *Othilia purpurea*, assigning it to the genus *Othilia*.

However, since the distinction between *Echinaster* and *Othilia* is rather subtle Fisher himself admits and *Othilia* is generally considered as a synonym for *Echinaster* of Muller and Troschel, the species *purpurea* is included under the genus *Echinaster* in the present account, *Othilia* being treated as a synonym for *Echinaster*.

Echinaster purpureus (Gray):

FIGURES 84 AND 85.

Othilia purpurea, Gray, Annals and Magazine of Natural History (I) VI, 1840, p. 282.

Echinaster Luzonica, Gray, Annals and Magazine of Natural History (I) VI, 1840, p. 282.

Echinaster fallax, Muller and Troschel, System der Asteroidea, 1842, p. 23; Perrier, p. 106.

Echinaster fallax, Savigny, Descr. del'Egypte Echinod., pl. 4, fig. 3.

Echinaster purpurea, Gray, Synopsis of the species of Starfish in the British Museum (Natural History), 1866, p. 12.

Echinaster Luzonica, Gray, Synopsis of the species of Starfish in the British Museum (Natural History), 1866, p. 12.

Echinaster purpureus, Bell, F. J., Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of "H. M. S. Alert", 1881-82, British Museum, 1884, p. 124.

Othilia purpurea, Fisher, "Starfishes of the Philippine Seas", Bull. United States National Museum, 100, Vol. 3, 1919, p. 432.

In the fresh, living condition, the colour of this species is purplish red, but it may also be purplish or reddish brown, and the specimens retain their natural colour in the dry-preserved condition. In alcohol, it is always darker in colour than other allied species, *Echinaster gracilis* and *Echinaster sepositus*. Very often specimens of *Echinaster purpureus* have six arms.

The arms are cylindrical, nearly three times as long as the width of the body, with numerous short, rather blunt spines; the under side of the body bears cross-wrinkles and two or three series of pores parallel to the ambulacra. Occasional freak specimens bear only four arms. Normally, the arms are five in number, but sometimes also six in number. The arms often bear many blunt spines.

Bell (*loc. cit.*), reporting on the specimens of this species collected by the "H.M.S. Alert" Expedition, states that while some specimens had six arms and another, five arms, not markedly differing in length, another had one very long arm, with a madreporite on either side of its base, and four shorter arms, of which one was very much shorter than the rest; he adds that the specimen, however, bore indications of injury and subsequent regeneration.

Fisher (*loc. cit.*), reporting on the Philippine specimens of this species furnishes some interesting details regarding the abactinal plates and granulation of the skin in this species:

The abactinal plates form roundish or more or less irregular meshes, 10 to 12 of which can be counted across the ray from one supero-marginal series to the other. These meshes are largest in the mid-radial region, and contain between five and ten papulae. Most of the abactinal and all the marginal plates bear a short, central, conical, blunt spinelet, heavily invested in membrane.

Just external to the adambulacral plates is a straight series of infero-marginal plates, about 10, corresponding to the 16 adambulacrals. These plates are four-lobed and extend from behind the mouth plates, where there is an odd plate, to the tip of the ray. The supero-marginal plates are immediately above, and separated by a series of papular areas, containing usually only a single papula (sometimes 2 or 3 at the base of the ray). Near the base of the ray, the supero-marginal series bends upwards and reaches the inter-radial line about midway between mouth and anus. The angular space between the two series is filled in with intermarginal plates and about 6 or 7 papular areas.

The skin contains crowded perforated plates having an irregularly elliptical, oval or subcircular form with ten or twenty perforations. Many are very irregular in the form of branched and perforated rods. These are incomplete plates. Fisher reports (*loc. cit.*), that if a light-coloured specimen is immersed for a short time in caustic potash, the crowded deposits can be readily seen with a strong hand lens as a minute greyish granulation in the skin. These deposits are reported to be slightly thicker around the edges of the papular pores where they form rings. Numerous glands are also seen scattered over the body.

The adambulacral armature consists of three spines. Deep in the furrow is a short, slightly curved, blunt, strongly compressed spine of a rather spatulate form, but oriented with the edge towards the furrow. The tip of this just reaches the base of the second spine which stands on the edge of the adambulacral plates and is stouter, longer, compressed and truncate at the tip. This series is united by thick membrane, and forms a serrate border to the furrow, the spines of one side usually fitting into the intervals between the spines of the opposite side. The spines of the same series are separated by a space about equal to their own thickness. Just back of them is the third spine, the bases almost touching, but as the outer spine is directed away from the furrow it appears in the undried and uncleared specimen to be considerably spaced from the second. The adambulacral plates are small, wider than long, and separated by an interval about one half their own length.

This species practices autotomy as is evidenced by the comet forms examined by Fisher in the collection from the Philippine Seas, both of which have the buds of five new rays.

This species has been recorded from the Indian Ocean and the Red Sea. Bell, reporting on the Alert Expedition specimens states that specimens of this species were collected from Port Moller, Port Denison and Thursday Island (4-6 fathoms deep). *loc. cit.*, records this species from Isle of France.

Fisher (oc. cit.), cites the distribution of this species as follows:—

Red Sea, Zanzibar, Mauritius, Mergui Archipelago, Madras, Philipines, Molucca Islands, Timor, Torres Strait, north east Australia, New Zealand.

Specimens in the collection.—Two specimens, exhibited in the Gallery, one from Tuticorin and the other from Kilakarai, are represented in the Museum collection.

(1) One dry-preserved specimen, exhibited in the Gallery. Locality: Tuticorin.

The specimen is dark brownish, closely covered with rounded, close-set tubercles, separated by deep pits. The arms are narrow, slender, cylindrical, gradually tapering towards the tip and sharply marked off from the greatly reduced disk. The arms are slightly curved towards the tip and almost serpentine.

Measurements: $R = 65$ mm.

$r = 9$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 120 mm.

(2) One wet-preserved specimen (preserved in alcohol) exhibited in the Gallery. Locality: Kilakarai, Ramanathapuram District.

The specimen is pale creamy white (probably faded due to preservation in alcohol). The other characters are more or less similar to those of the dry-preserved specimen described above. The arms are slender, narrow and pointed towards the tip, and sharply marked off from the greatly reduced disk. The ambulacral grooves are narrow and brownish. This is a much smaller than the preceding dry-preserved specimen, and is probably a young specimen.

Measurements: $R = 31$ mm.

$r = 6$ mm.

Overall diameter from tip of one arm to tip of opposite arm: 56 mm.

ORDER FORCIPULATA

The sea-stars belonging to this Order are distinguished from all other Asteroids by the presence of typical pedicellariae provided with a basal piece and two valves. The pedicellariae have crossed jaws. The marginal plates are inconspicuous. Generally, these sea-stars have a small disc and elongated tapering arms, with rounded sides, and hence they are devoid of a definite margin and conspicuous marginal plates. The skeleton is reticular, usually arranged in the arms in transverse arches, and mostly also showing more or less regular longitudinal series such as carinals and marginals. The mouth frame is usually of the ambulacral type. The podia occur in two or four rows in each ambulacral groove and are provided with simple ampullae. Papulae usually occur throughout the surface.

Of the four families included in this Order, only one, the Zoroasteridae, comprising deep water forms, is represented in the Museum collection, by a single genus and species, namely *Zoroaster planus*.

Family ZOROASTERIDAE

This family includes deep sea Asteroids characterized by a small disk and five long slender arms in which the plates are arranged in longitudinal rows. Pedicellariae, when present, are of the straight type only. There are usually four rows of podia in each ambulacral groove. The aboral surface may be either with or without spines. Members of this family generally inhabit muddy bottom in deep water both on the Pacific Coasts of the United States and in the Indo-Pacific Regions.

Genus *Zoroaster* Wyville Thomson.

The disk is small. The arms are long, narrow, tapering throughout, arched abactinally, and with a more or less definite median keel, tumid actinally. The interbranchial areas are acute.

Abactinal, marginal and actinal intermediate plates are arranged in regular longitudinal rows along the arm. Regular transverse series are also formed, the plates being correspondent and equal in length in each series as they proceed along the arm, excepting the plates in the median series, which are longer. The surface of all the plates is covered with small, widely spaced granules upon which are articulated small, papilliform, skin-covered spinelets. A small, robust, conical spine may be borne on the plates of the median series, the supero-marginal series and sometimes on the intermediate abactinal series of plates; and one or more longer, delicate, tapering spines are usually present on each of the actinal intermediate plates.

The adambulacral plates are small, and quite within the furrow, and each alternate plate may be produced and form a prominent ridge which extends far into the furrow (this character is probably only fully developed in the adult). The adambulacral armature consists of several elongate spines placed in a single file along the edge of the ridge; and one or two small ciliary spinelets at the extreme edge of the plate. The intermediate, rather inconspicuous plates bear only this small group of ciliary spinelets, and are devoid of spines on the surface of the plate within the furrow.

The Madreporiform body is small and inconspicuous, placed external to the inter-radial (basal) plate.

The anal aperture is small, excentric, surrounded by a circlet of small, ciliary spines.

Small, forciform pedicellariae are present on the abactinal surface, one or occasionally two being borne on the membrane in each mesh, punctured by the papulae.

Several small, forciform pedicellariae are attached by membrane to the innermost spine of the armature of the adambulacral plates.

The ambulacral tube feet (podia) are small, with a fleshy terminal disk and forming four rows.

This genus was for a long time known only from the Atlantic. But Sladen reported (in his Challenger Reports, 1899), a new form from the Eastern Archipelago. All the species are from great depths.

The genus *Zoroaster* was originally classified and included by Sir Wyville Thomson in the Asteriidae. It was subsequently referred by Perrier to the family Pedicellasteridae, established by him in 1884. In the following year, 1885, it was, however, removed by Perrier into the new family Stichasteridae. According to Sladen, however, *Zoroaster* and its allies are very far removed from *Pedicellaster*, and although in some of their characters they approach much more nearly *Stichaster*, he is of the opinion that the details of their structure justify the establishment of an independent family, the *Zoroasteridae*.

Species of this genus have been recorded from the Atlantic and the Pacific Oceans. The bathymetric range of the genus is from 33 to 2326 fathoms. Most species are confined to the abyssal zone. One or two species extend to the littoral zone also.

A single species, *Zoroaster planus*, is represented in the Museum collection by a single specimen in a rather badly damaged condition, from South Ceylon.

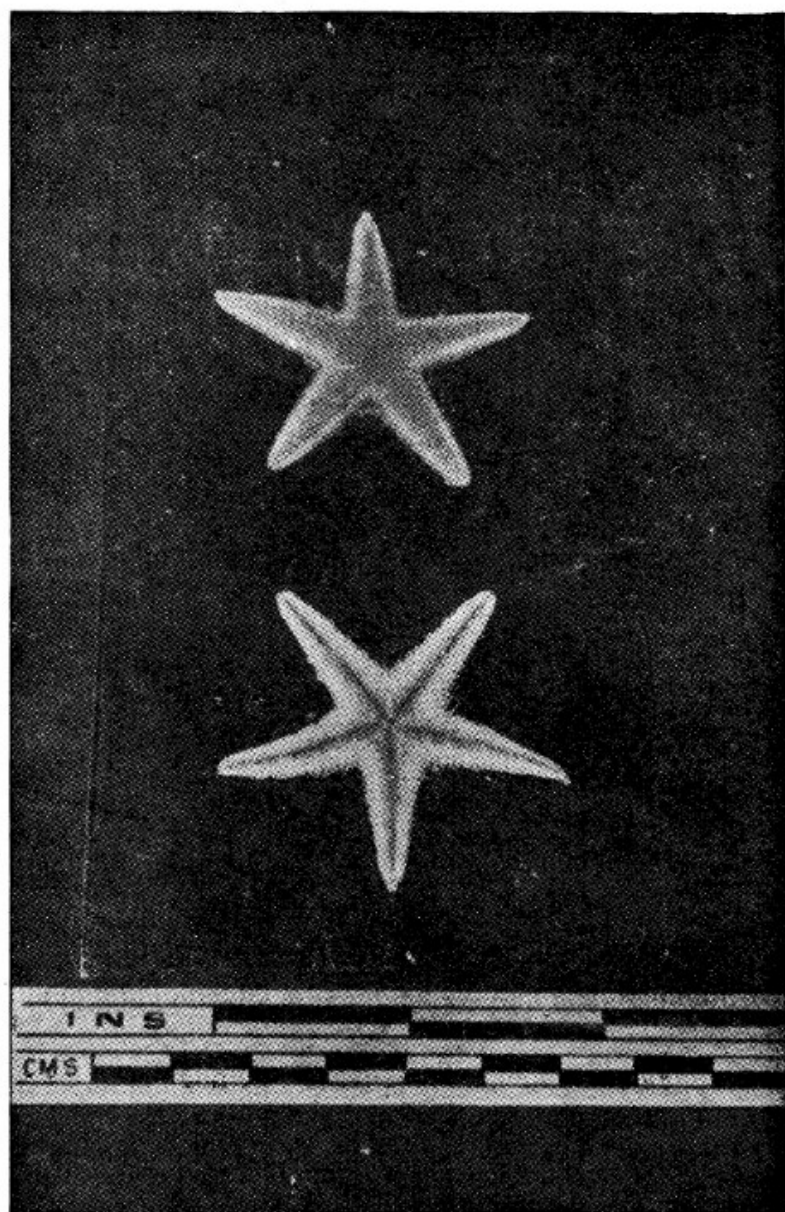


Fig. 57. *Astropecten indicus* Döderlein.
(Above : Dorsal view ; Below : Ventral view).

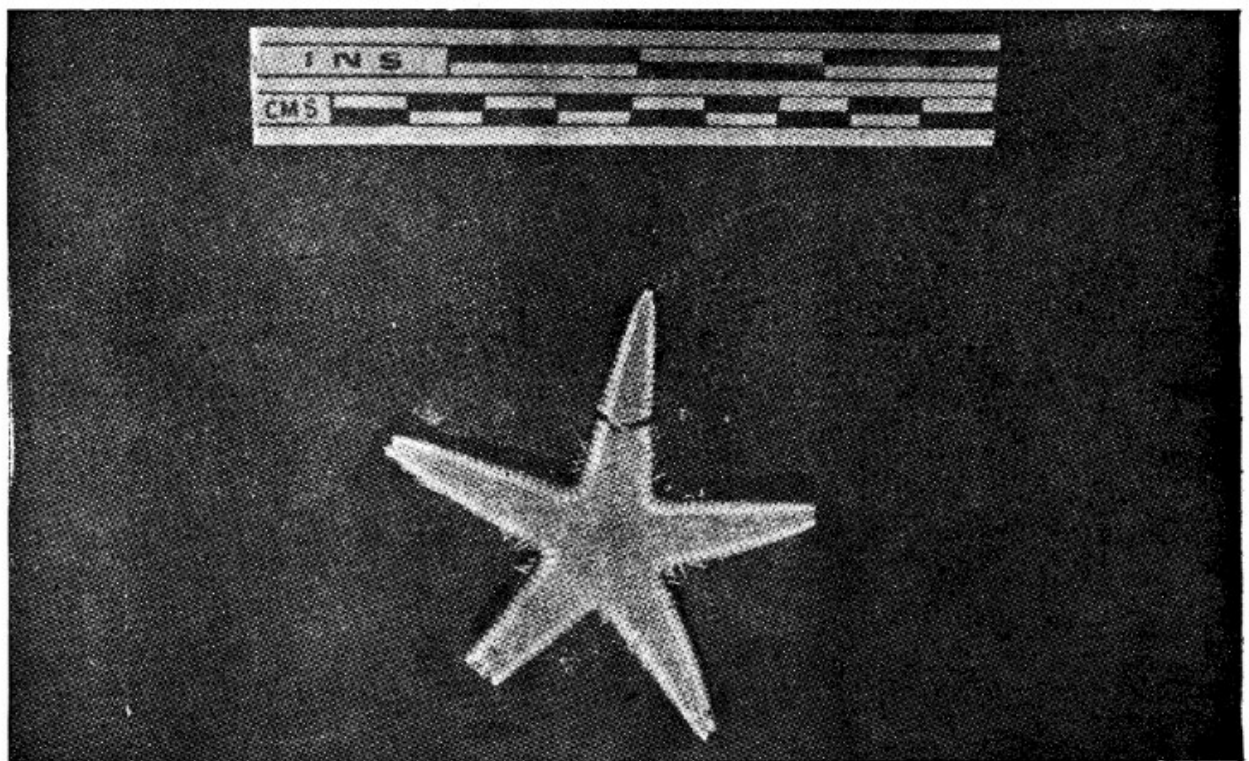


Fig. 58. *Astropecten mauritanus* Gray.
(Dorsal view).

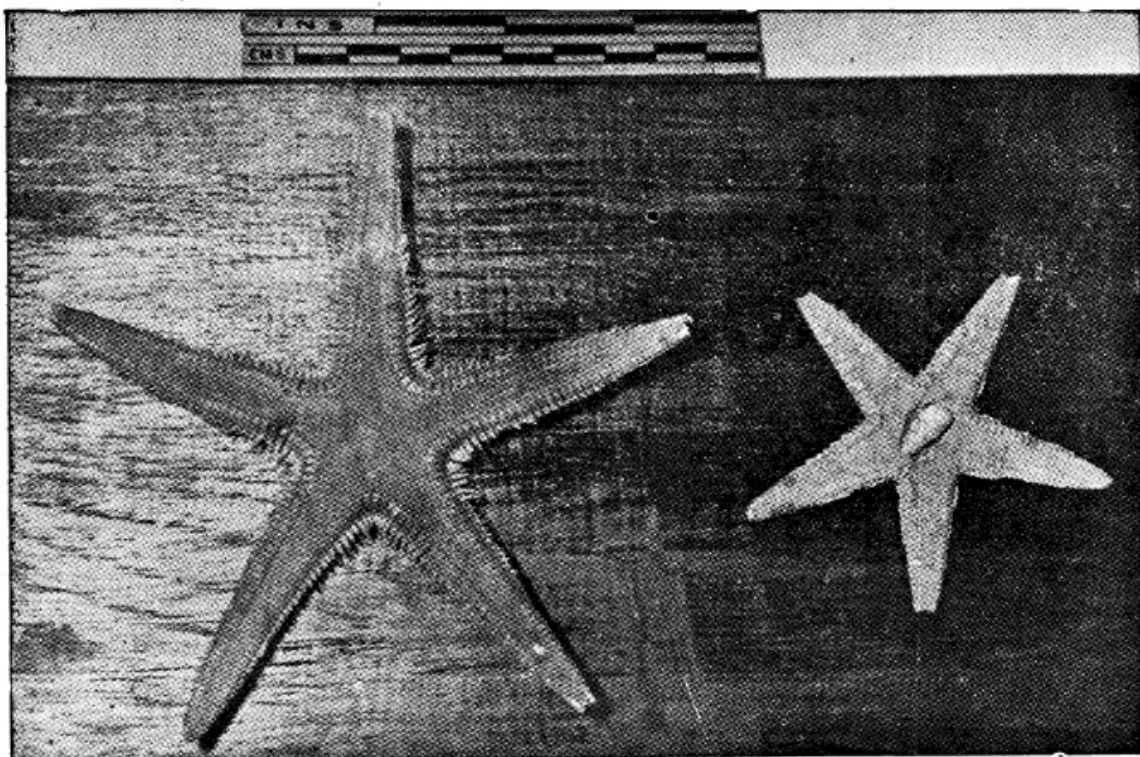


Fig. 59. *Astropecten hemprichii* Muller and Troschel.
(Both specimens : Dorsal view).

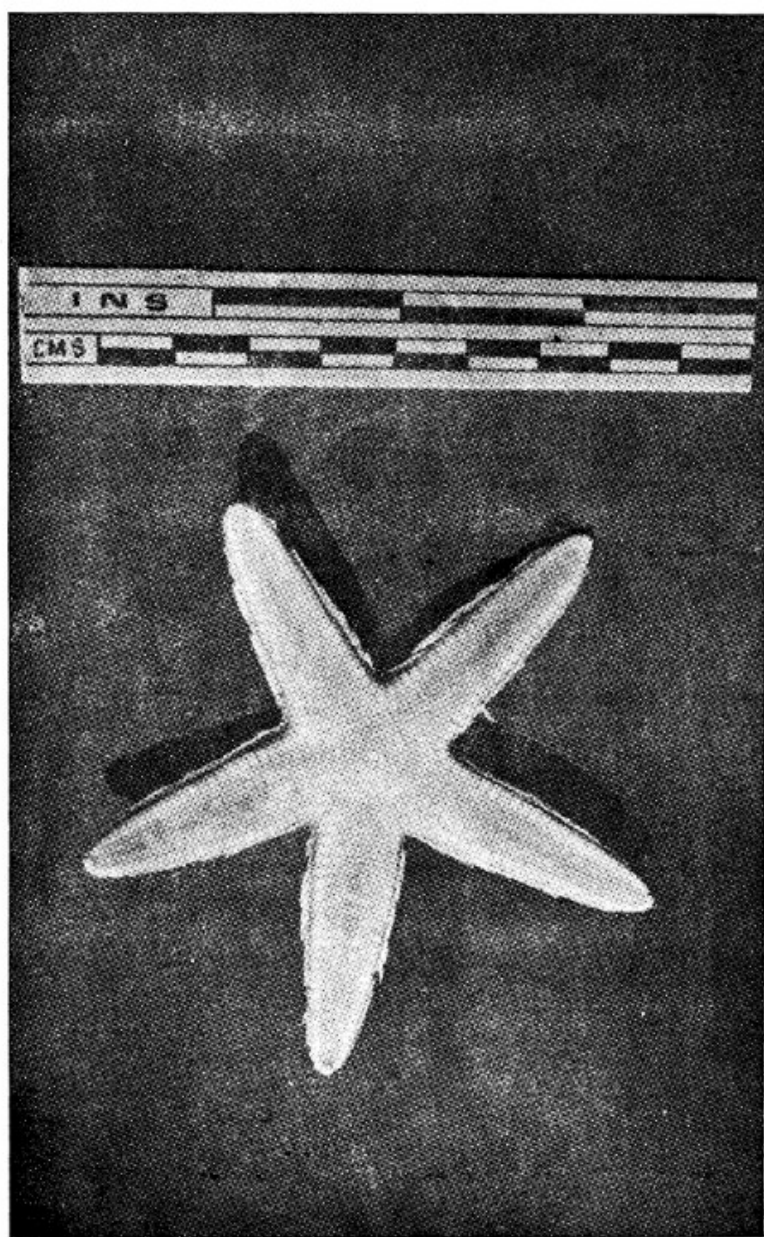


Fig. 60. *Astropecten monacanthus* Sladen.
(Dorsal view).

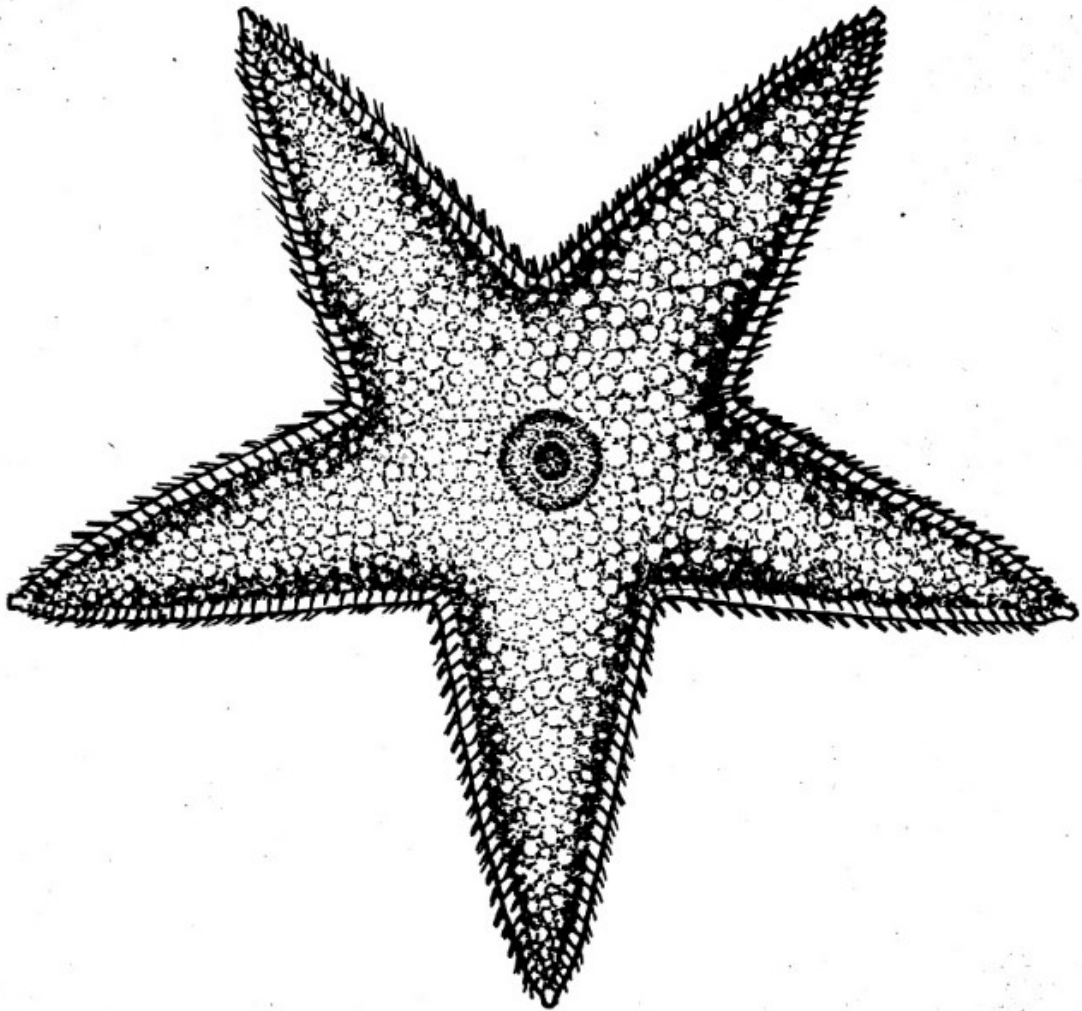


Fig. 61. *Astropecten zebra* Sladen.
(Dorsal view) ($\times 3$).

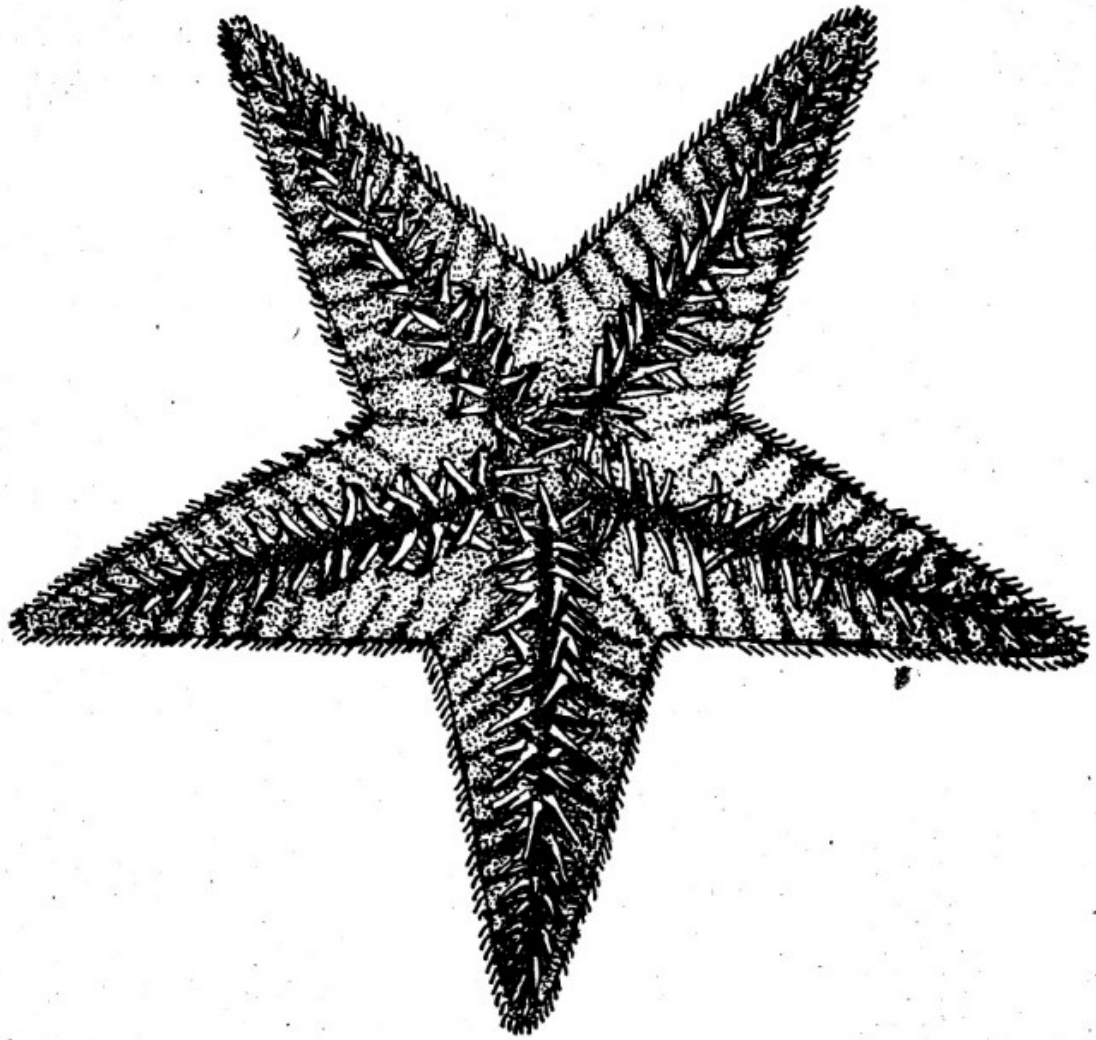


Fig. 62. *Astropecten zebra* Sladen.
(Ventral view) ($\times 3$).



Fig. 63. *Persephonaster rhodopeplus* Woodmason and Alcock.
(Dorsal view of damaged specimen).

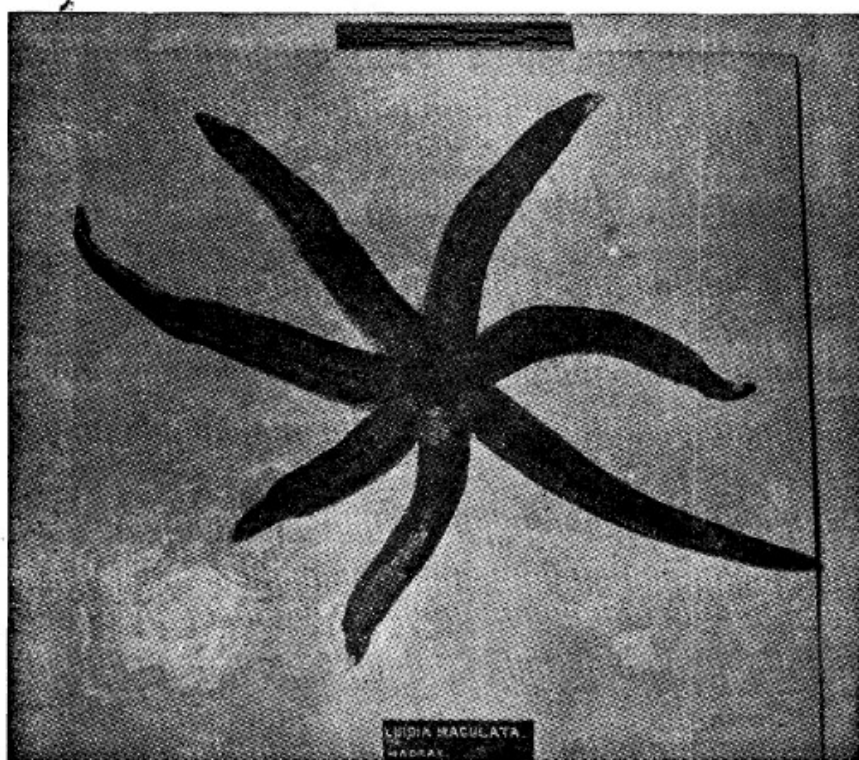


Fig. 64. *Luidia maculata* (Muller and Troschel).
(Dorsal view).



Fig. 65. *Luidia savignyi* (Ardouin).
(Dorsal view).

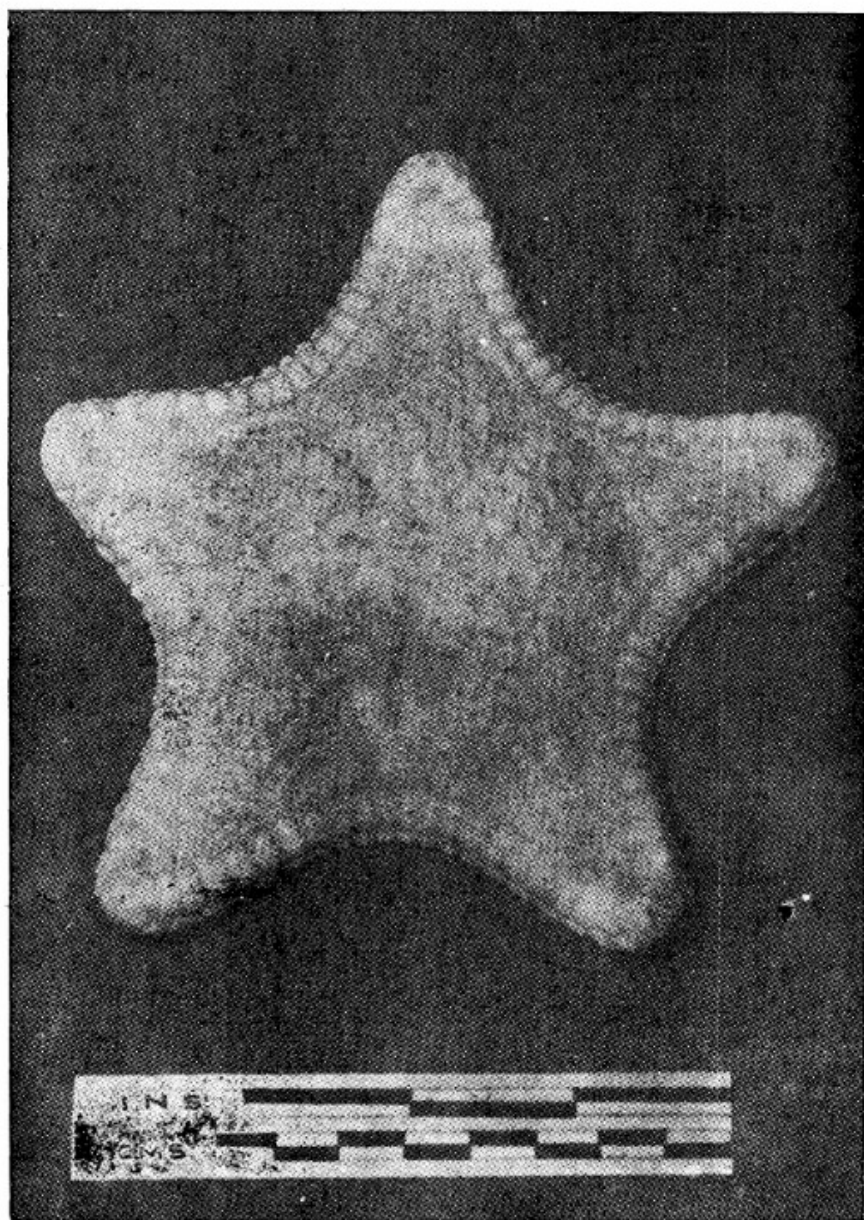


Fig. 66. *Anthenea regalis* Koehler
(Dorsal View).

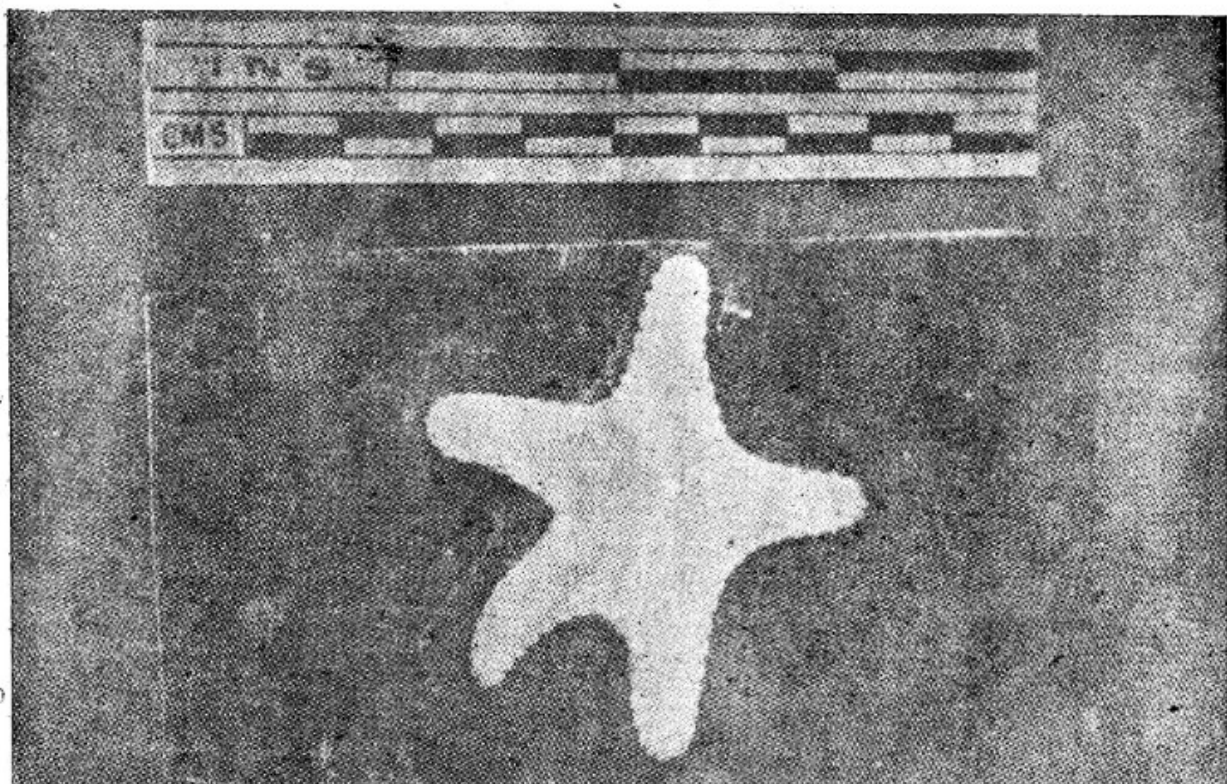


Fig. 67. *Anthenea rudis* Koehler.
(Dorsal View).

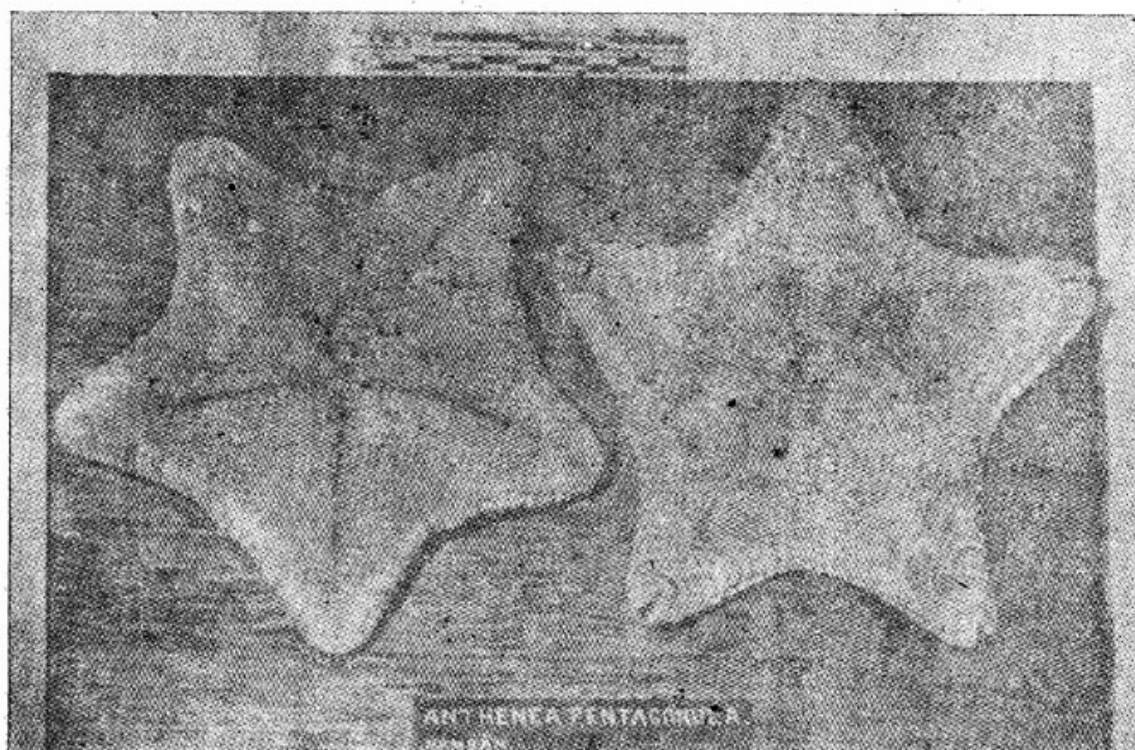


Fig. 68. *Anthenea Pentagonula* (Lamarck).
(Left: Ventral view; Right: Dorsal view).

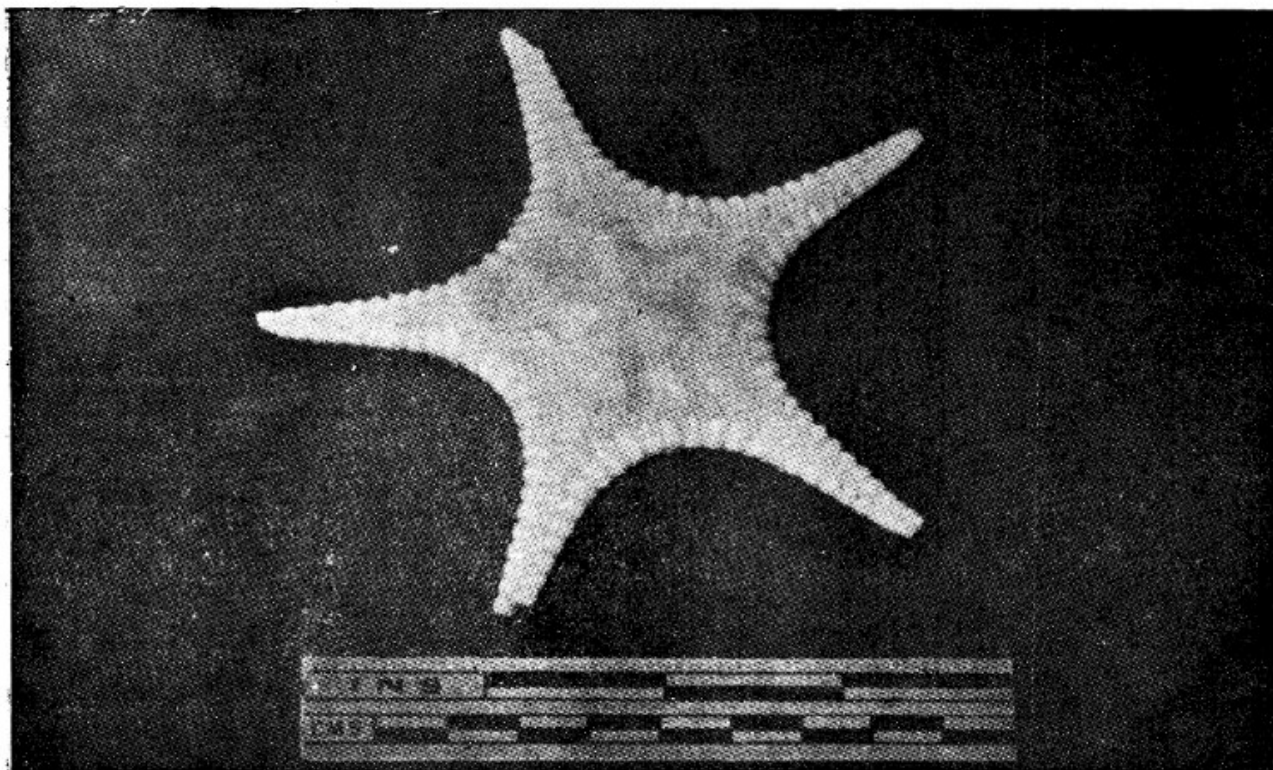


Fig. 69. *Stellaster belcheri* Gray.
(Dorsal View).

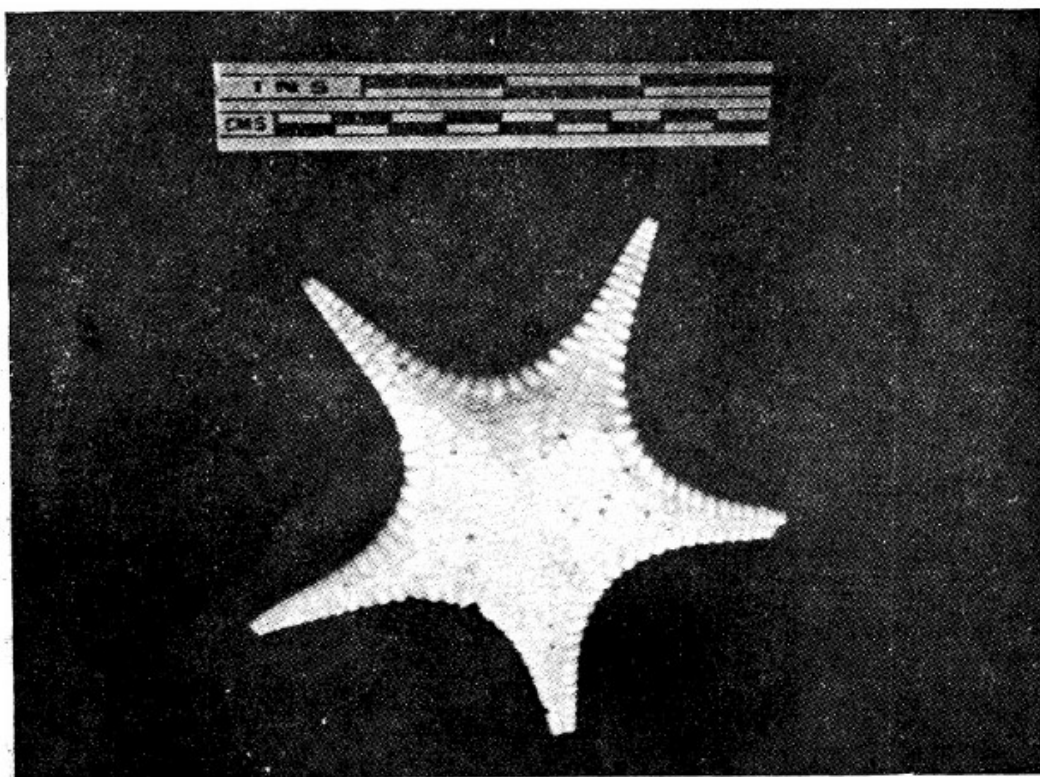


Fig. 70. *Stellaster inaei* Gray.
(Dorsal View).

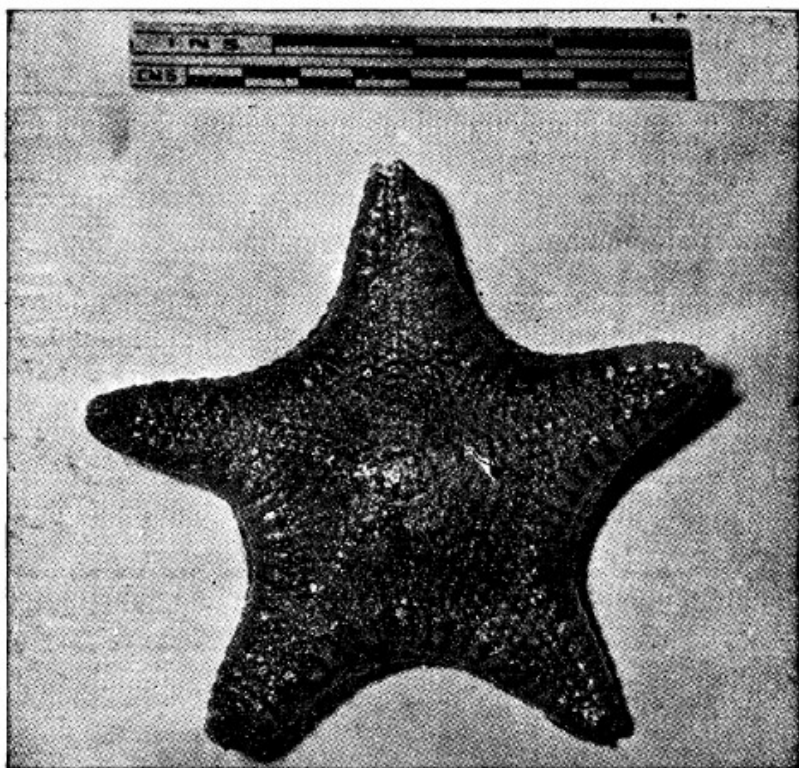


Fig. 71. *Goniodiscus granuliferus* (Gray).
(Dorsal View).

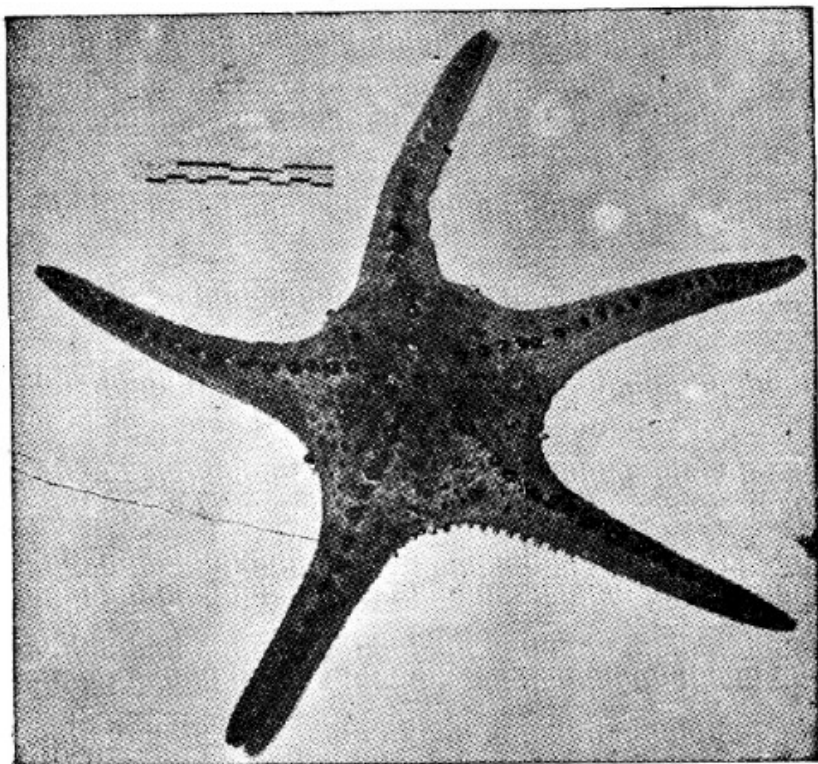


Fig. 72. *Pentaceraster multispinus* (Von Martens).
(Dorsal View).

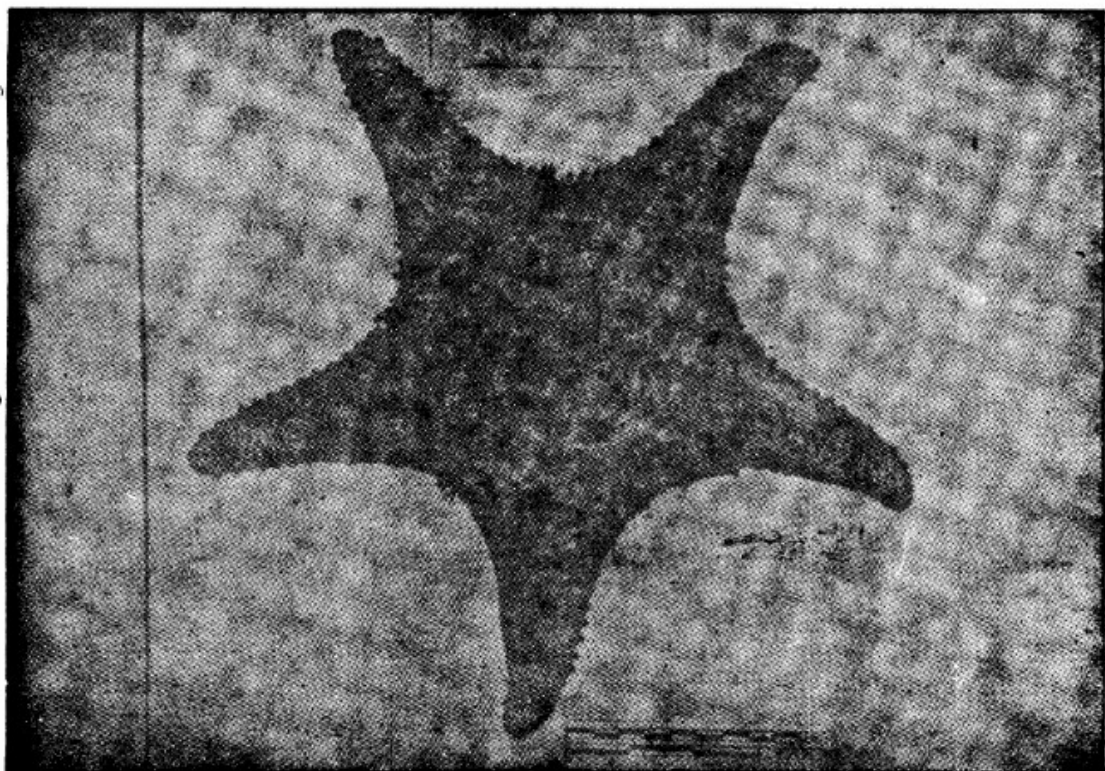


Fig. 73. *Oreaster thurstoni* Bell.
(Dorsal view).

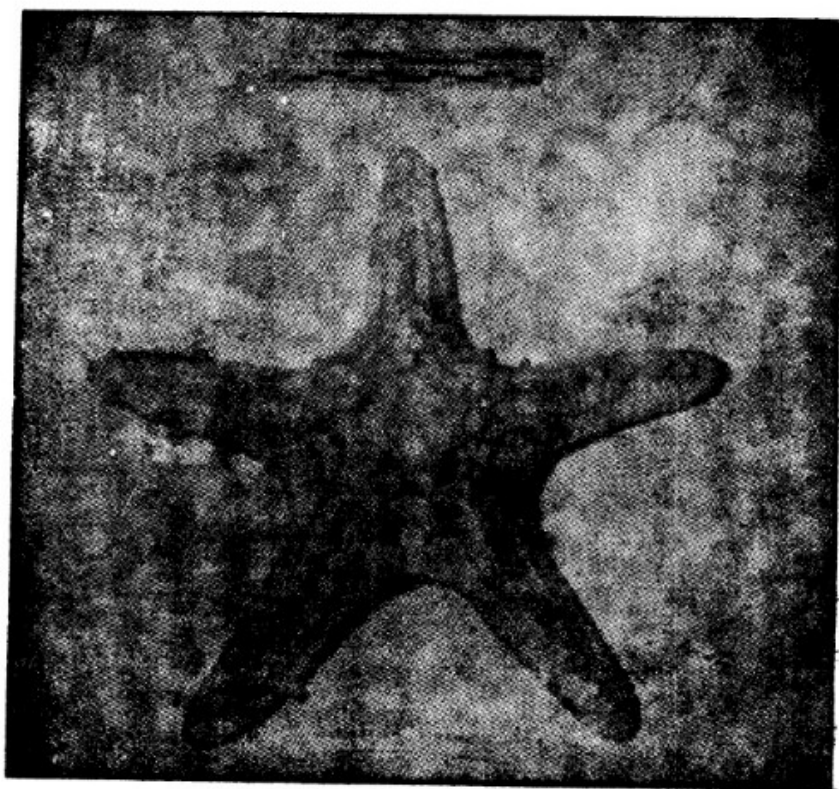


Fig. 74. *Protoreaster lincki* (de Blainville).
(Dorsal view)
(Specimen from Kilakaral).

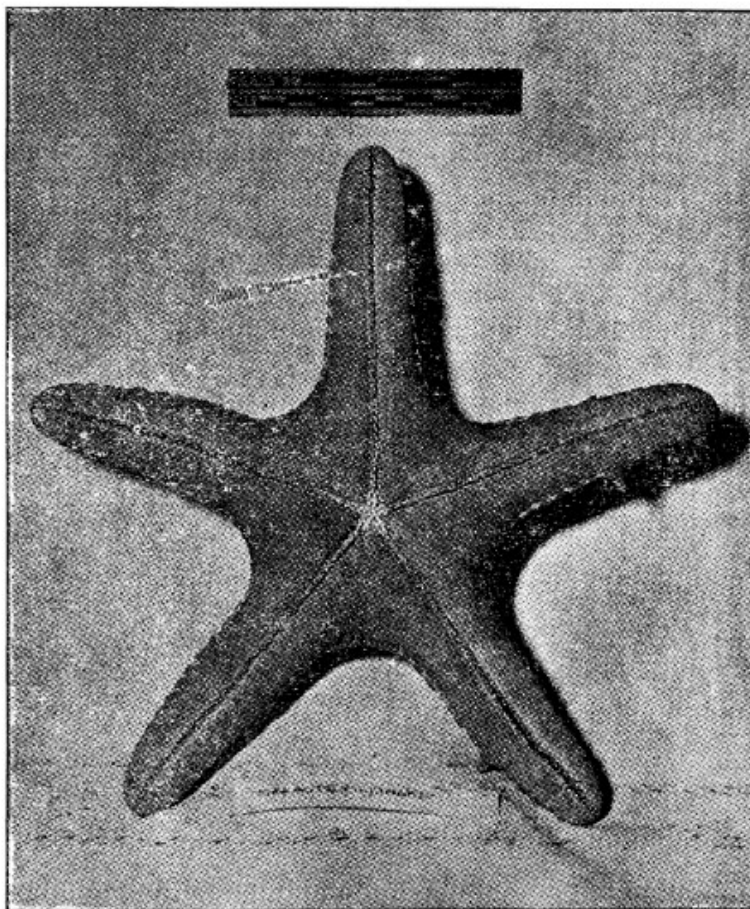


Fig. 75. *Protoreaster lincki* (de Blainville).
(Ventral view).

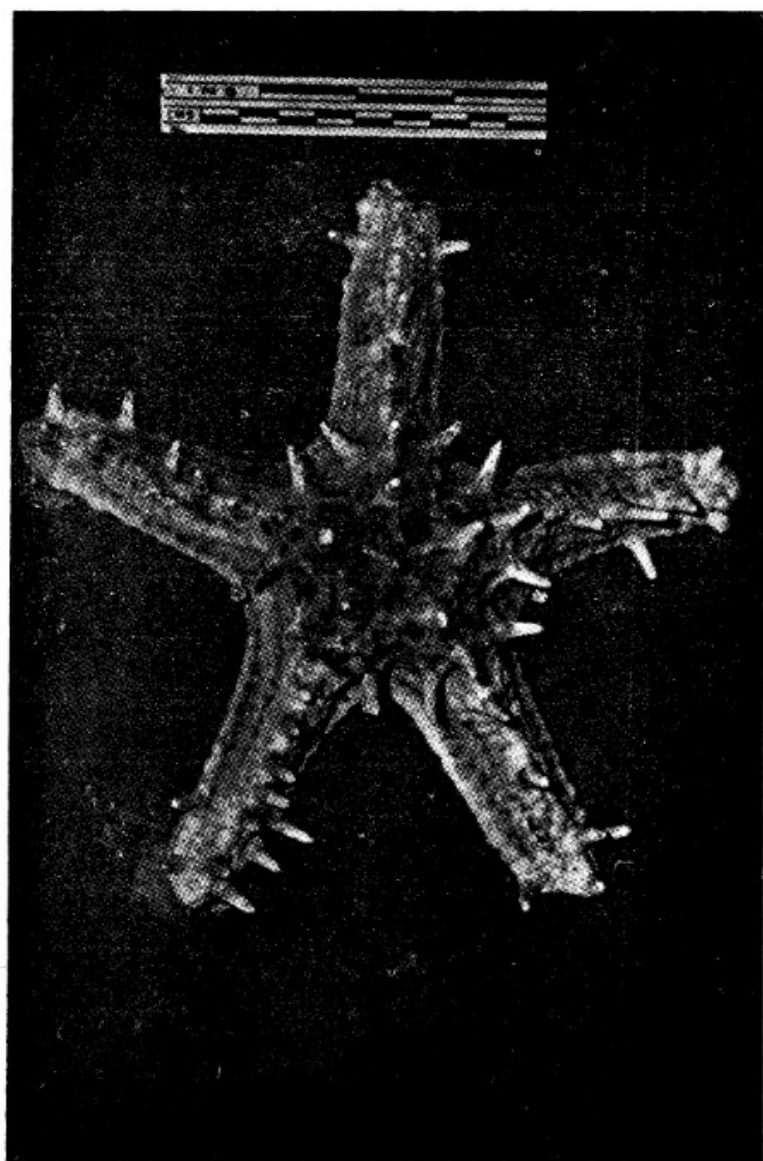


Fig. 76. *Protoreaster lincki* (de Blainville).
(Dorsal view).
(Specimen from Tuticorin).

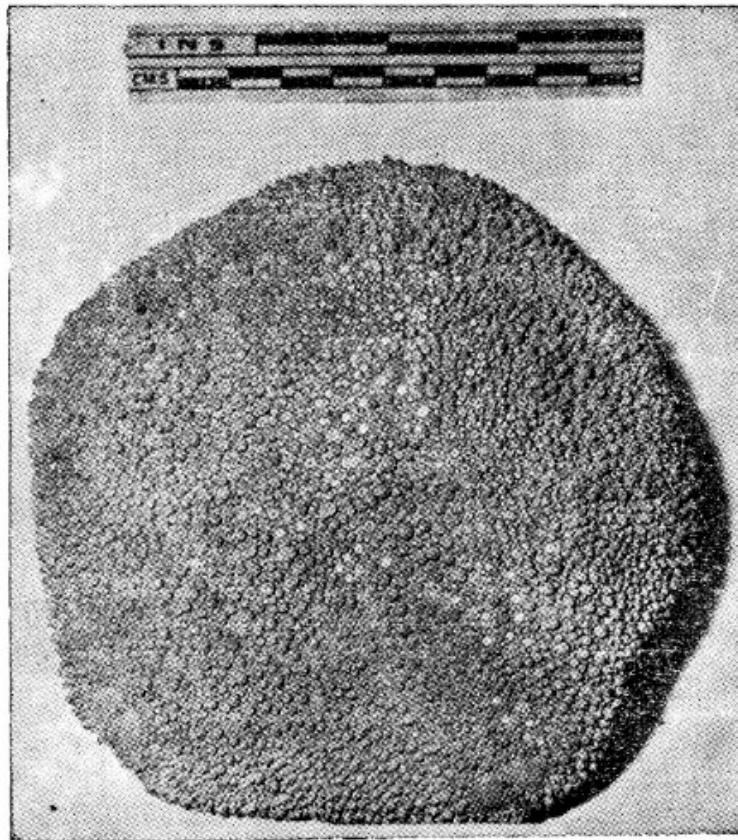


Fig. 77. *Asterodiscus elegans* (Gray).
(Dorsal view).

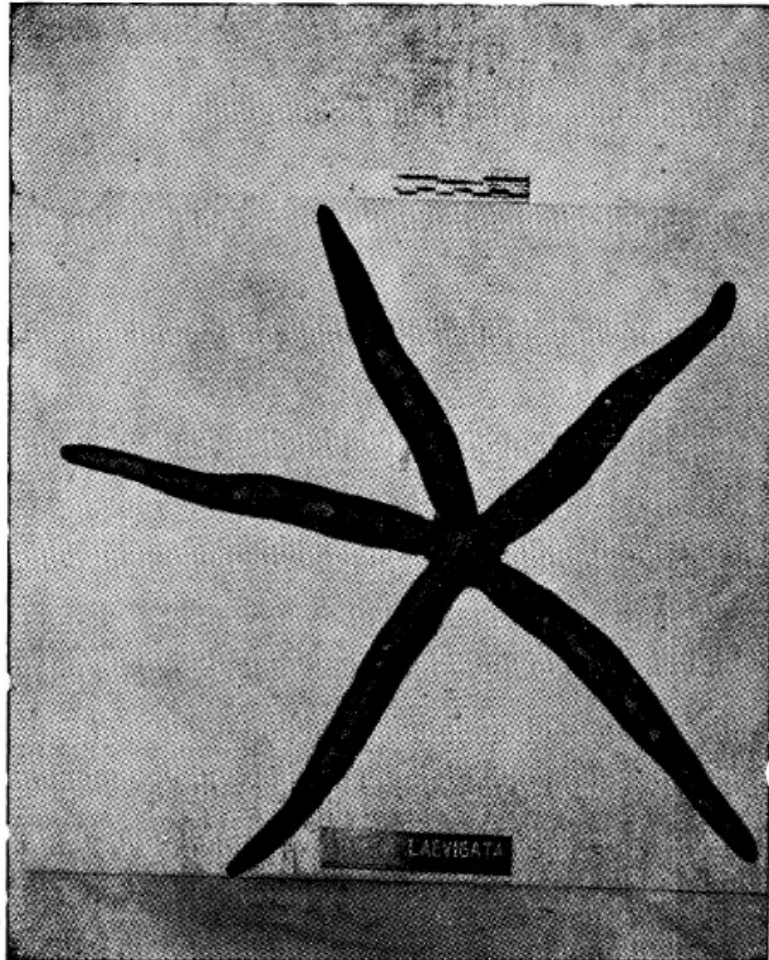


Fig. 78. *Linckia laevigata* (Linnaeus).
(Dorsal view).

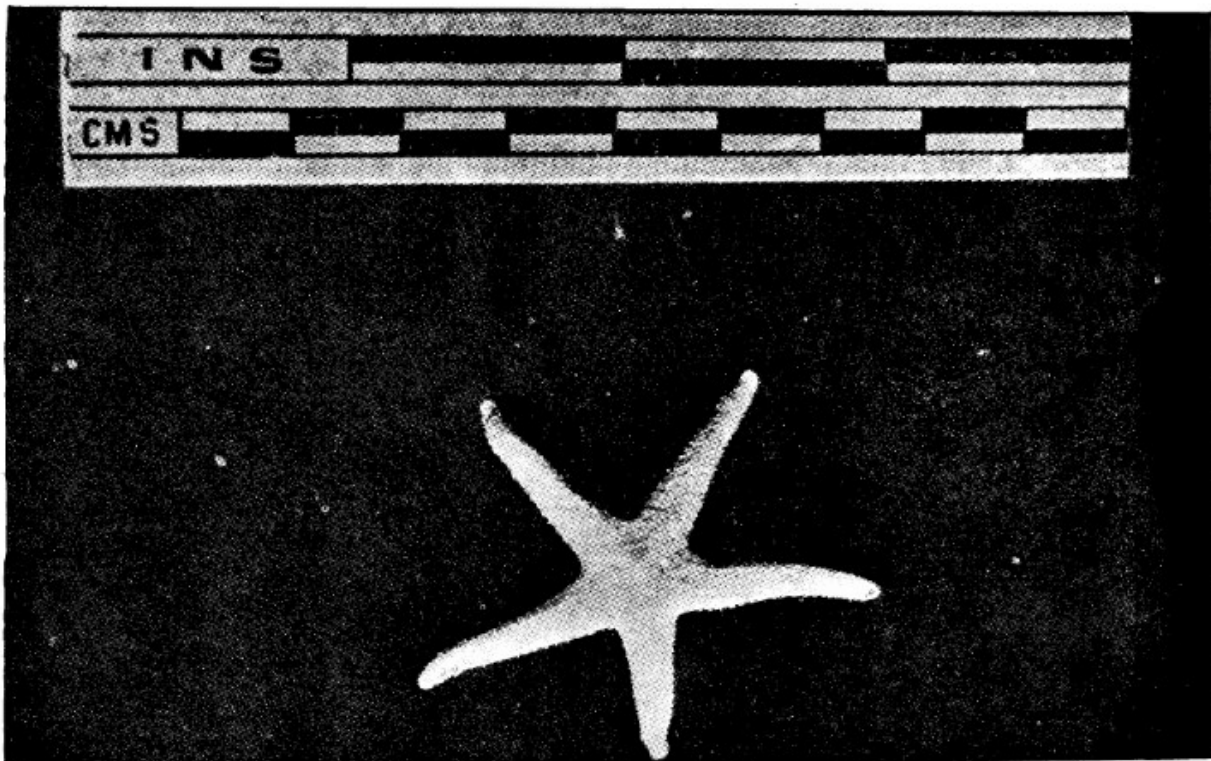


Fig. 79. *Metrodora subulata* (Gray).
(Dorsal view).

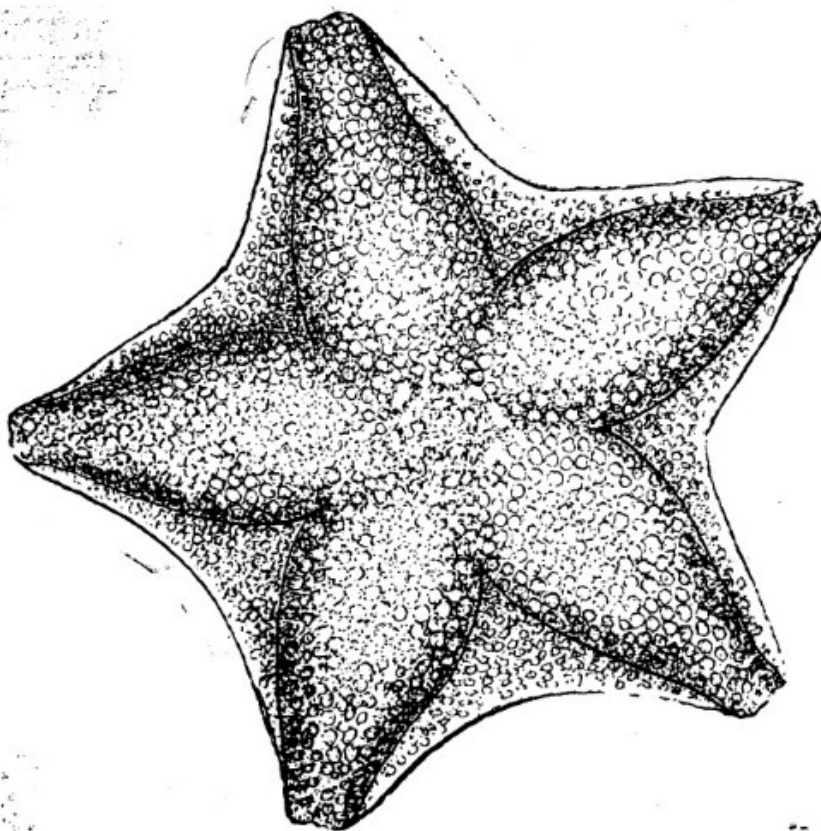


Fig. 80. *Asterina cepheus* (Muller and Troschel).
(Dorsal view) ($\times 4$).

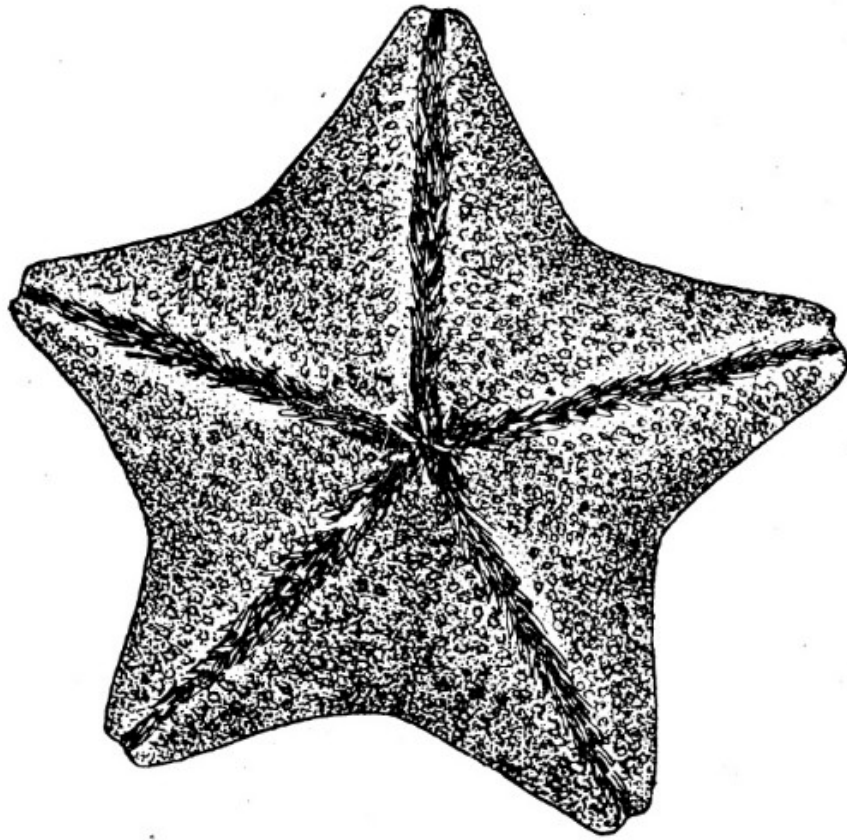


Fig. 81. *Asterina cepheus* (Muller and Troschel).
(Ventral view) ($\times 4$).

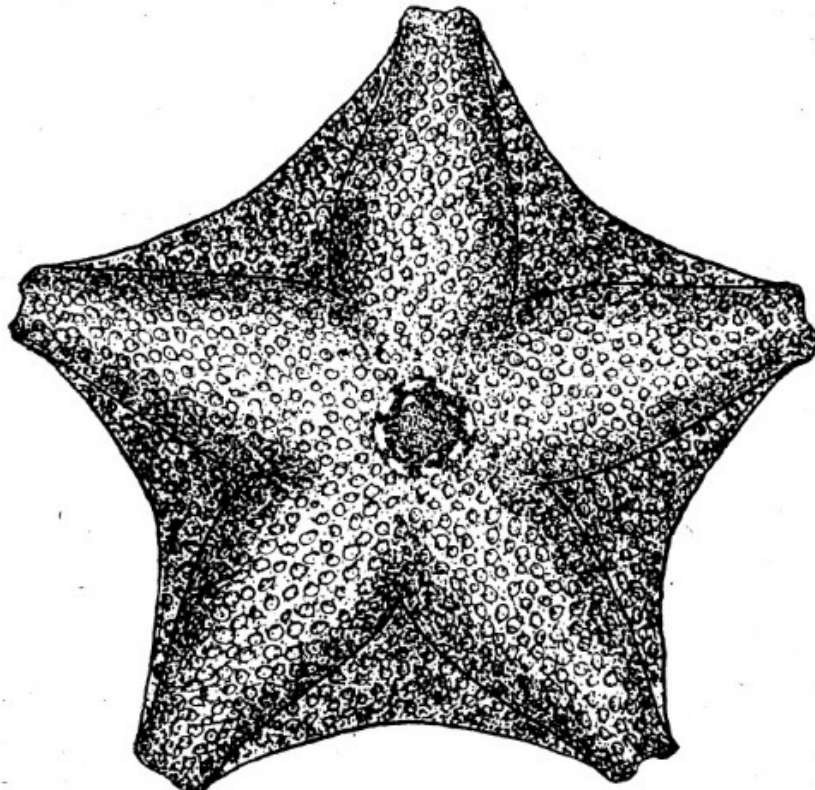


Fig. 82. *Asterina coronata* (Von Martens).
(Dorsal view) ($\times 4$).

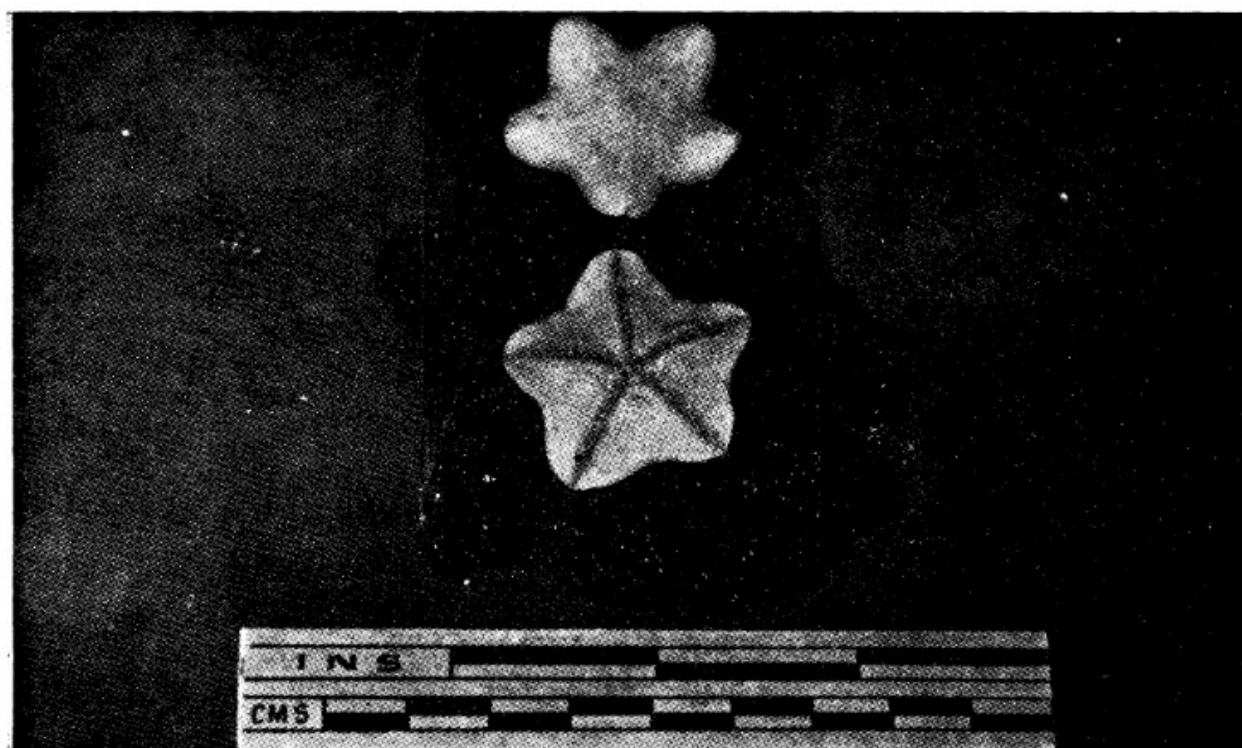


Fig. 83. *Anseropoda sarasini* (de Loriol).
(Above: Dorsal view; Below: Ventral view).

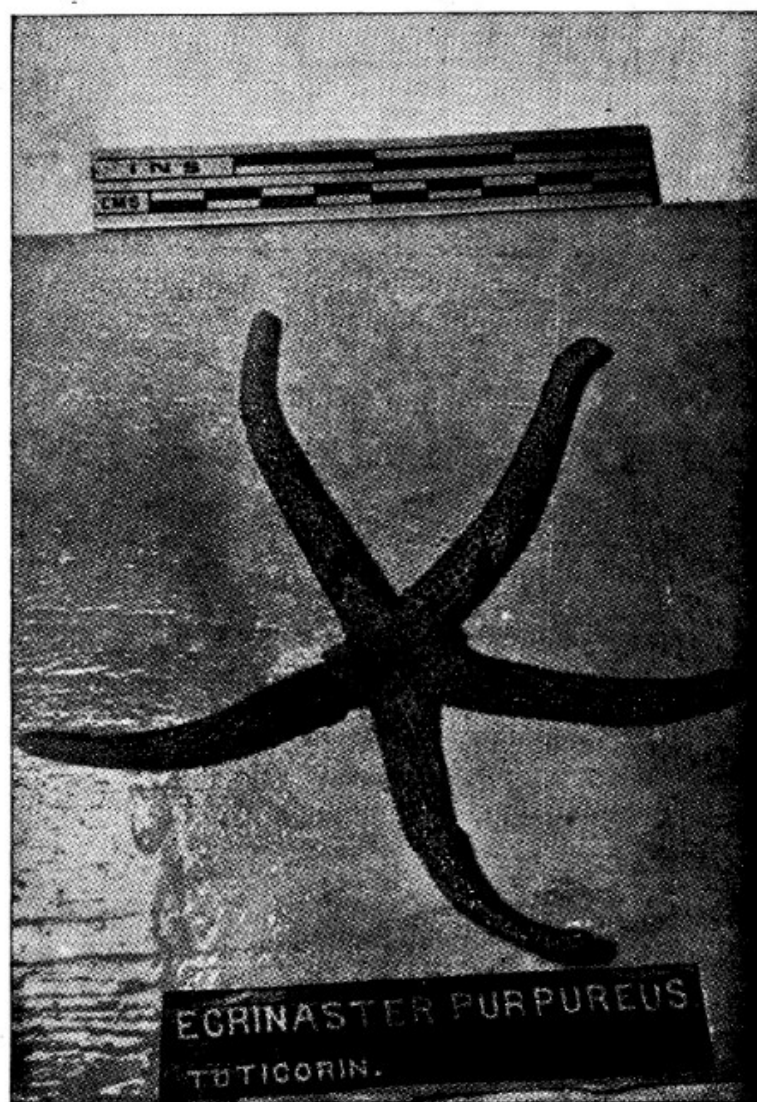


Fig. 84. *Echinaster purpureus* (Gray).
(Dorsal view.)

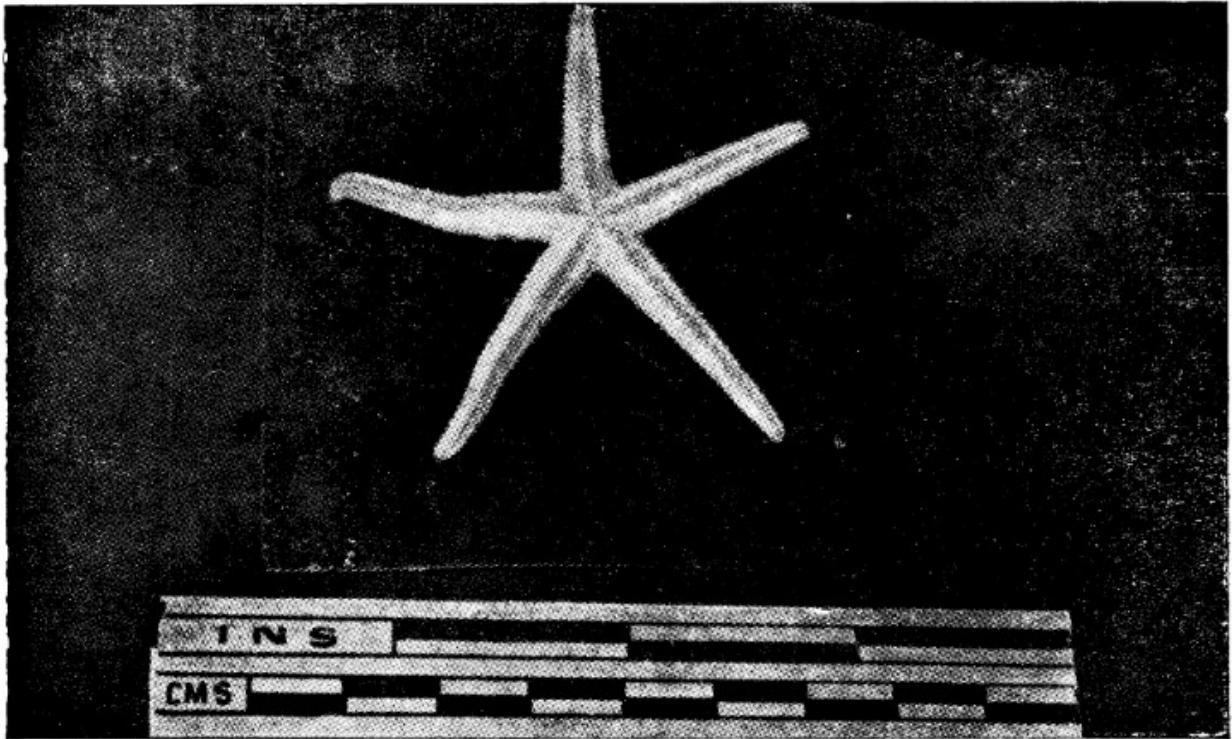


Fig. 85. *Echinaster purpureus* (Gray).
(Ventral view).

Zoroaster planus Alcock.

Zoroaster planus, Alcock, "Indian Deep Sea Asteroidea", Annals and Magazine of Natural History; (6) Vol. XI 189 104.

The rays are five in number. In the type specimen, described by Alcock (*loc. cit.*), $R = 16 r$; $R =$ being equal to 210 millimetres.

The disk is extremely small, depressed; the rays are extremely long, and fairly tapering, semicylindrical, depressed.

The abactinal surface of the disc bears slightly enlarged, close-set, sub-hexagonal, primary radials and interradials, surrounding a mass composed of a dorso-central and radial under-basal plates, all of equal size; all the plates are rather closely covered with capillary spinelets, and the dorso-central radial plates carry, in addition, a stout, conical, fluted spine; the narrow intervals between neighbouring plates each bear one papula and often also a single large pedicellaria.

The rays have a longitudinal mid-radial row of large, tumid plates, each of which bears, besides the capillary spinelets, a central stout, conical, fluted spine, much like a pedicellaria; on each side of this row are six (seven in the interbrachia, five at the end of the rays) very close, parallel rows of smaller plates, the lowest row articulating with the adambulacral; these plates, which also fall into transversely parallel series are rather distantly covered with capillary spinelets, the central one of which in each plate (except in the row immediately adjoining the large, mid-radial series) becomes a long, slender spine that gradually increases in size in each successive row from the abactinal to the actinal surface. The narrow intervals between the angles of neighbouring plates give passage (except between the two lowermost rows of plates) each to one papula, and (on the plates) between the papulae is a rather large pedicellaria.

The adambulacral plates are short and do not extend far upwards within the furrow; each plate bears on its actinal edge two transversely placed spinelets and occasionally a pedicellaria, and every alternate plate has a prominent inter-ambulacral ridge on which is borne a row of three spinelets, the innermost being furnished with a cluster of eight small pedicellariae, and the one next the innermost with a single large pedicellaria. The mouth plates are armed with large, needle-like spines.

The tube feet (podia) are quadri-serial (i.e., arranged in four rows).

The Madreporiform plate is large, tumid and conspicuous, with a coarse, peach-stone sculpture.

The colour of the specimens in life is salmon-red.

This species has been previously recorded from the Laccadive Sea, at a depth of 1,200 fathoms in coral and amidst *Globigerina* ooze. This is a fairly deep sea species.

This species is very much like the closely allied species *Zoroaster Barathri*, from which, however, it is easily distinguished (i) by the flattened disk very definitely delimited from the bases of the rays; (ii) by the large, prominent, madreporiform plate; and (iii) by the large spinelet borne centrally on every plate except the basal interradials and the plates of the row immediately adjoining the mid-radial row on each side.

Specimens in the collection.—One specimen (wet-preserved) is contained in the Reference Collection, from South Ceylon, in a rather badly damaged condition.

The arms are very fragile and many of them are broken at the tip. The specimen is soft and the arms are in a flexible and disintegrating condition. The general colour of the preserved specimen is a dull grayish brown. The arms are long, fairly thick at

the base and distinctly demarcated from the disk which is comparatively small. The individual plates forming the skeleton of the arms and the disk are distinctly visible in the present specimen.

The general shape and proportions of the disk and arms and the general appearance of the specimen very much resemble those of *Persephonaster rhodopeplus*, which is also represented in the Museum collection and which is also, similarly, a deep sea form.

Measurements: $R = 68$ mm.

$r = 20$ mm.

Diameter of the disk: 28 mm.

CLASS OPHIUROIDEA

According to Bather's classification in Lankester's Treatise on Zoology, the Ophiuroids are treated as a subclass of the larger class, Stelleroidea, which, according to this classification, includes the Asteroidea also.

But according to the modern system, the Ophiuroidea are treated as a distinct Class of the Echinodermata.

The Ophiuroidea are Eleutherozoan Echinoderms of stellate form with slender, simple or branched arms sharply marked off from the disc, as appendages. The arms differ from those of the sea stars (Asteroidea) in not having a groove along their ventral side, and in being of solid construction, and supported by an internal row of ossicles, without ambulacral grooves. The podia are reduced to small papillae not provided with ampullae. The Ophiuroids are without anus or intestine or any digestive tubes extending into the arms.

The typical Ophiuroids (Order Ophiuræ) have a small, flattened, disk of rounded, pentagonal or scalloped outline, sharply separated from the five symmetrically placed, long, slender, smooth or spiny arms. In the Basket-stars (Order Euryalæ), the disk is larger and the arms are branched repeatedly forming an elaborate network.

The tube feet (podia) are arranged in two rows; they are sensory and non-locomotory, having no suckers: pedicellariæ are wanting. The stomach is sac-like, without caecæ or extensions into the arms. The madreporite is on the oral side.

The aboral surface of the disk may be smooth and leathery, or covered with small spines, or may bear a number of plates embedded in the integument. The arms are always long in proportion to the disc and sometimes they may be very long. They present a jointed appearance, being composed of four longitudinal series of calcareous plates or shields. The arms may be smooth or may bear spines on their lateral shields to a varying degree.

The Ophiuroidea are free-living, active creatures, and are commonly known as serpent stars from the snake-like appearance of the slender arms and their flexuous, serpentine movement, or as brittle stars from the tendency of the arms to break off readily. About 1800 living and 180 fossil species are known.

The Ophiuroids are mostly small animals with a disk about 10 to 30 millimetres in diameter and the arms normally about three to five or six times the diameter of the disk in length; however, species with small disks may sometimes have very long arms. The basket stars (Gorgonocephalidae) of which there is one species represented in the Museum collection, are very much larger than the typical Ophiuroids, having disks up to ten centimetres in diameter, and with much branched and coiled arms.

The Class Ophiuroidea is divided into two Orders—the Ophiurea which includes the typical Ophiuroids and by far the greater majority of the species and the Euryalae which includes the Basket stars. Both Orders are represented in the Museum collection, the former by twelve species, belonging to five different families, and the latter by a single species, belonging to the family Gorgonocephalidae.

ORDER OPHIURAE

This Order comprises the typical brittle stars or serpent stars and includes by far the great majority of the species of serpent stars. The arms are simple, unbranched, mostly five in number, but sometimes six or more, moveable chiefly in the transverse plane, but they cannot twist or turn to the mouth. The disk and arms are usually covered with distinct shields or scales, although these may sometimes be covered with skin or by a layer of granules or by spines. The arm spines are borne on the lateral shields and project outwards or towards the tip of the arms. There is only one madreporite.

As mentioned earlier, five families of this order are represented in the Museum collection, namely, the families Amphiuridae, Ophiactidae, Ophiothricidae, Ophiocomidae and Ophiodermatidae.

These families may be distinguished from one another by the following chief diagnostic characters:—

- | | | |
|--|----|-----------------|
| 1. Disk generally definitely scaled with radial shields which are evident, and which at their outer ends are articulated by a socket to a ball-shaped projection of the outer ends of the genital plates | 2. | |
| Disk scalation more or less completely concealed either by little spines or tubercles, or by close-set granules | 3. | |
| 2. Two oral papillae at the jaw apex | | Amphiuridae. |
| Only one oral papilla present at the jaw apex | | Ophiactidae. |
| 3. Disk scalation more or less concealed by little spines or tubercles; oral papillae are wanting; the arms are spiny with mostly long, thorny spines of glassy appearance | | Ophiothricidae. |
| Disc scalation more or less completely concealed by closely set granules; oral papillae are present in large numbers; spines not as above, but may either be strong, stiff and solid or small and closely appressed to the sides of the arms | 4. | |
| 4. Relatively large and conspicuously coloured Ophiuroids with spiny arms bearing strong, generally solid spines; oral papillae merging into a large cluster of tooth papillae | | Ophiocomidae. |
| Smaller and more dull-coloured Ophiuroids, with arms appearing relatively smooth, as the arm spines are small and closely appressed to the sides of the arms; oral papillae are numerous and in a continuous row, but tooth papillae are wanting | | Ophiodermatidae |

Family AMPHIURIDAE

The Amphiuroidae are distinguished by long, slender, flexible arms with short, erect spines. The disk is generally definitely scaled with clearly visible radial shields. These shields are articulated at their outer ends by a socket to a ball-shaped projection of the outer ends of the genital plates. Oral papillae are present, two of which occur at the jaw tip. They are followed along the edge of the jaw by a single row of square teeth, as tooth papillae are lacking. The oral papillae are one to five in number, of which the last is generally infra-dental. The arms are inserted on the ventral side of the disc. Dental papillae are absent.

The Ophiuroids belonging to this family generally live buried in sand or mud with the arm tips protruding.

A single genus of this family, namely, *Amphioplus*, is represented in the Museum collection by a single species, *Amphioplus gravelyi*, specimens of which have been collected from Krusadai Island and from Pamban, in the Gulf of Manar. Formerly these specimens were referred to the species *Ophiophragmus relictus* under which name they had been described in the Bulletin entitled "Littoral Fauna of Krusadai Island", Vol. I, No. 1, 1927, by Dr. Gravelly who originally collected the specimens. *Ophiophragmus* is a synonym for *Amphiura* under which name the species are recorded in Koehler's and Lyman's Monographs, and the genus *Amphiura* Forbes, is, in its turn, partly a synonym for the genus *Amphioplus*.

Genus *Amphioplus* Verrill.[=*Amphiura* Forbes (Part)]

The disc is small and delicate, covered with naked, overlapping scales, and furnished with uncovered radial shields. Teeth are present, but there are no tooth papillae. The mouth angles are small and narrow, and bearing a few (usually four or six, rarely eight or ten) close-set, small mouth papillae. The arms are long, slender, even and more or less flattened. The arm spines are short and regular. Two genital openings are present in each inter-orbital (interbrachial) space. The scales along the edge of the disc are turned upwards, so as to make a little fence-like border.

The disc wall is encased with fine, regular, overlapping scales and large, flat, elongated radial shields, having at their outer end, a small knob which marks their articulation to the long, slender, flattened, club-shaped genital plate. To this last is fastened an equally long, slender, blade-like scale. The three arm bones nearest the disc margin have their tips elongated outward. The tops of the mouth frames, though small, are considerably furrowed and grooved, but are devoid of a peristomial plate, or have only a thin line crust. A short, small jaw which is characteristic of this genus, supports the intimately connected jaw plate and the large, flat, oblong teeth. All the species have a genital plate of the general shape just described.

The genus *Amphioplus* is characterized by the presence of four or more oral papillae; along each jaw edge, and is treated by Koehler himself as a Section of the genus *Amphiura* in his Monograph on the Ophiuroidea of the Siboga Expedition (Koehler, *loc. cit.* 1905).

Amphioplus gravelyi James.

FIGURE 86.

Ophiophragmus relictus, Gravelly, "Littoral Fauna of Krusadai Island, in the Gulf of Manar", Bull. Mad., Govt., Mus., I, No. 1, 1927, p. 170.

Amphioplus gravelyi, James, D. B., Journal of the Marine Biological Association of India, 1970, XII, Nos. 1 and 2, p. 139.

Dr. Gravely (*loc. cit.*, 1927) originally referred these specimens (collected by him in the Gulf of Manaar, and contained in the collections of the Madras Museum) to the species *Ophiophragmus relictus* of which *Amphioplus relictus* Koehler is a synonym. Koehler ("Ophiurans of the Philippine Seas and adjacent waters", Bulletin of the United States National Museum, 100, Vol. 5, 1922, p. 179), has placed this species in the genus *Amphioplus* and gives a detailed discussion as to why it cannot be placed in the genus *Ophiophragmus* and explains how the arrangement of the mouth papillae necessitates placing it in the genus *Amphioplus*. However, *Amphioplus relictus* is at present regarded as a synonym for *Amphioplus depressus*, and the species to which the Madras Museum specimens belong have been referred to a new species, namely *Amphioplus gravelyi* by D.B. James (*loc. cit.*, 1970).

Many of the characteristic features of *Amphiura*. *Amphioplus* and *Ophiophragmus* approximate each other very closely, and there is still some uncertainty in the correct determination of these genera

D. B. James (*loc. cit.*, 1970) has clarified the position with regard to the present species and has described it as a new species, *Amphioplus gravelyi*, and hence this species is described under this currently accepted name in the present account also.

The following extracts on this species are therefore quoted from D. B. James's paper cited above, as his description is based on the type specimens of this species contained in the collection of this Museum, which were originally referred to, and described as, the species *Ophiophragmus relictus* (Koehler) by Dr. Gravely. (*loc. cit.*, 1927).

"Gravely (1927) in his account on the Echinoderms of Krusadai Island in the Gulf of Manaar reported the occurrence of a brittle star, *Ophiophragmus relictus* (Koehler). Under synonymy for this species he included *Amphiura relictus* Koehler. *Amphiura relictus* is currently regarded as a synonym of *Amphioplus depressus* (Ljungman). A re-examination of the specimens of Dr. F. H. Gravely at the Madras Museum revealed that they were not *A. depressus* but belonged to an undescribed species of *Amphioplus*. They are named here as *Amphioplus gravelyi* after Dr. F. H. Gravely who collected the specimens. The types are present in the reference collections of the Madras Government Museum".

D. B. James has based his description of this new species on two specimens having disc diameters of 8 and 9 mm. and with the length of the arms being 100 and 110 mm. respectively. In the smaller specimen the dorsal covering of the disc is lost. They have been collected in September, 1925 by Dr. Gravely from Krusadai Island and Pamban (in the Gulf of Manaar) respectively. The following is a description of this species as furnished by D. B. James (*loc. cit.*, 1970):—

The disc is five-lobed with numerous small imbricating scales. At the centre of the disc there is a small circular scale. Surrounding this scale and placed radially in position there are five circular scales forming the first circle. Alternating with these five scales there is a second circle of five other scales interradially arranged at some distance from the first circle. The size of these large scales is found to vary from 0.35–0.42 mm. The scales surrounding the radial shields are slightly larger than the other scales present on the disc. The scales at the margin of the disc are very small. The radial shields are long, pointed at the proximal end and they remain separated throughout their length. In between each pair of radial shields there is a row of three scales. The ratio of breadth to length of each radial shield is 1 : 4 — 1 : 4.2. The ratio of the length of each radial shield to the diameter of the disc is 1 : 4.1.

The interbrachial areas on the ventral side are completely covered with small imbricating scales.

There are four oral papillae on each side of the jaw. They are arranged in a row without leaving any space. Of these, the infra-dental papillae are the largest and oval in shape. The distalmost papilla is the smallest of the four and situated on the adoral shield.

The middle two papillae are of the same size and are more or less circular in shape. The oral shield is large and pear-shaped. The adoral shields are slightly smaller, three-sided and meet interradially.

The dorsal arm plates are broadly elliptical proximally, with the proximal and distal margins convex and the distal plates are fan-shaped. The dorsal arm plates are contiguous with the successive plates. The ratio of the length to breadth of the proximal plates is 1:2.2, and for the distal arm plates it is 1:1.4 — 1.1.6.

The first ventral arm plate is very small and three-sided. The proximal ventral arm plates are rectangular and contiguous. The ratio of breadth to length of each plate is 1:1. There are two tentacle scales for each tentacle pore. The outer tentacle scale lies along the lateral arm plate and is slightly larger than the inner one which lies along the side of the ventral arm plate.

The first two free segments have five spines and the next eighteen segments have four and the rest three spines. The spines are small, smooth, cylindrical and pointed. When there are four spines the third from the upper side is spatulate and when there are three spines the middle spine is spatulate. The length of the three spines on the twentieth segment from the upper side is 5.49, 5.12 and 3.92 mm. respectively. At the tip of the arm all the three spines are smooth, cylindrical and pointed. The ratio of the longest spine to the segment length is 1:1.2.

The colour of the specimens in rectified spirit is whitish."

Discussion.—The present species resembles *Amphioplus stenaspis*, a closely allied species in having small radial shields which are separated throughout their length and in having shields which meet radically. In *A. stenaspis* the spines are "short and blunt", while in *A. gravelyi* they are spatulate as in the case of *A. iustus*. But *A. gravelyi* differs from *A. iustus* in the presence of distinct primary plates and separate radial shields. The spatulate spines of *A. gravelyi* are very characteristic. They are flattened with fairly serrated margin. The tips of the spines are rounded, slightly expanded, and at the corner of each spine there are one or two small teeth. *Amphioplus gravelyi* can be separated from all the known species by the presence of distinct primary scales, small separate radial shields and the characteristic spatulate spines.

Specimens in the collection.—Two specimens are represented in the Reference Collection (formerly identified and labelled as *Ophiophragmus relictus* (Koehler), collected by Dr. Gravelly, one from Pamban (1925) and the other from Krusadai Island (1925). Both are wet-preserved, but are in a mutilated condition.

(1) In the specimen from Krusadai Island all the arms except one have got separated from the disc. The specimens are dull greyish brown (in spirit), but the sides (i.e. the lateral edges) of the arms are marked by deep rufous brown (or chocolate brown) lines. The disk is small, somewhat pentagonal and granular above, bearing five radial depressions with a median raised whitish streak or ridge extending towards the bases of the five arms. The spines are moderately large, thick, whitish and regularly arranged at the sides of the arms. The under surface of the arms and disk are paler brown, almost dull whitish brown. The mouth aperture is very small, almost minute, with five narrow slits radiating from it towards the bases of the arms. The arms are extremely slender, very long in proportion to the diameter of the disc. and serpentine with narrow, pointed tips.

Measurements: Diameter of the disc: 8 mm.

Length of the arm: 115 mm.

(2) The other specimen from Pamban is still more badly mutilated and consists only of the detached arms and a fragment of the disc and portions of one or two arms attached to it.

Family OPHIACTIDAE

This is a small family and is often included under the Amphiuroidae. The members of the family Ophiactidae differ from those of the Amphiuroidae chiefly in having but one papilla at the jaw apex. In other characters they more or less resemble the Amphiuroidae. Many species, especially of the genus *Ophiactis*, exhibit pronounced fissiparous tendencies.

A single genus, *Ophiactis*, is represented in the Museum Collection by a single species, *Ophiactis savignyi*.

Genus *Ophiactis* Lütken.

The disc is circular, robust, closely covered with radial shields and overlapping scales, the latter bearing usually a greater or less number of small spines. Teeth are present, but there are no tooth papillae. The mouth angles are small and narrow, and bearing a few (usually two or four) small mouth papillae. The arms are stout, somewhat flattened, of moderate length (four to seven times the diameter of the disc). The arm spines are stout, smooth and solid. Two genital openings are present, beginning outside the mouth shields.

With regard to the disc scales and radial shields, the arrangement resembles that of *Ophiopholis* (especially in *Ophiactis asperula*), though other species such as *Ophiactis cuspidata* have much larger and stouter scales. There is a resemblance similarly, in the peristomial plate which is wanting in some species such as *Ophiactis kroyeri*, or is reduced to a mere thin crust as in *Ophiactis savignyi*, or is small and linear, as in *Ophiactis asperula*. The genital plate is usually very stout, though long, slender and cylindrical in *Ophiactis kroyeri*, and has, attached to it, a considerably shorter genital scale. The arm bones are discoidal and delicate, with thin wings.

The single species of this genus represented in the Museum Collection, *Ophiactis savignyi*, is fairly widely distributed in the Indo-Pacific Region.

Ophiactis savignyi.—Falls under the first type, according to Mr. Lyman's arrangement, in which the number of the mouth papillae increases with age.

Ophiactis savignyi (Müller and Troschel).

FIGURE 87.

Ophiactis Savignyi, Müller and Troschel, System der Asteroidea, 1842, p. 95; Savigny Descr. del' Egypte, Echin., pl. ii, figs. 4-5.

Ophiactis sexradia, Grube, Wieg. Archiv., 1857, p. 343.

Ophiactis sexradia, Lütken, Addit. ad Hist., pt. 2, p. 126; Lyman, Ill. Cat. Mus. Comp. Zool., Harvard, No. 1, p. 115.

Ophiactis Reinhardti, Lütken, Addit. ad Hist., part 2, 1859, p. 161; pl. iii, fig. 7.

Ophiactis Krebsii, Lütken, Vid., Meddel., 1856, p. 12, Addit. ad Hist., part 2, p. 126; Lyman, Illustr. Cat. Mus. Comp. Zool., No. 1, p. 111, figs. 10-11.

Ophiactis virescens, Orst. & Lütken, Vid. Meddel., March, 1856, p. 24; Addit. ad Hist., part 2, p. 128; VII, Transactions of the Connecticut Academy, I, part 2, p. 265.

Ophiactis savignyi, Ljun., Oph. Viv. Of. Kong. Akad., 1866 p. 323.

Ophiactis incisa, Von Martens, Wieg. Archiv., 1870, p. 248.

- Ophiactis savignyi*, Russo, Echinodermi raccolti nel mer, Rosso. Boll. Soc. Naturalisti, Napoli, VII, 1894, p. 161.
- Ophiactis sexradia*, Russo, Ibid., 1894, p. 161.
- Ophiactis virens*, Russo, Ibid., 1894, p. 161.
- Ophiactis krebsii*, Verrill, "Additions to the Echinoderms of the Bermudas", Transactions of the Connecticut Academy, X, p. 186.
- Ophiactis Krebsii*, Verrill, "Report on the Ophiuroidea collected by the Bahama Expedition, Iowa City", Bull. Laborat. Nat. Hist., Vol. V, No. 1, p. 34.
- Ophiactis savignyi*, Lyman, "Challenger Reports", Ophiuroidea, Zoology, 1882, pp. 113-115.
- Ophiactis savignyi*, Bell, F. J., "Echinodermata", Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H. M. S. "Alert", 1881-1882 (British Museum, London, 1884), p. 138.
- Ophiactis savignyi*, Koehler, Siboga-Expeditie, "Ophiures Littorales", Siboga-Expeditie, XLV b (= livr. XXI), 1905, pp. 26-29.
- Ophiactis savignyi*, Koehler, R., Echinides, Ophiures et Stellerides recueillis par M. Gravier dans le mer Rouge (Golfe de Trajurah), Bulletin du Museum, Paris, 1905, p. 184.
- Ophiactis savignyi*, Koehler, R., Ophiures Zool. Jahrb. Suppl. Vol. 11, 1913, p. 351.
- Ophiactis savignyi*, Koehler, R., Echinodermata I, Beitrage zur Kenntnis der Meeresfauna West-africas, Hamburg, 1914, p. 184.
- Ophiactis savignyi*, Clark, H. L., "The Echinoderms of Ceylon other than Holothurians", Spolia Zeylanica, Vol. 10, part 87, 1915, p. 90.
- Ophiactis savignyi*, Koehler, R., "A Contribution to the Study of Ophiurans of the United States National Museum", Bull. United States National Museum, 84, 1914, p. 41.
- Ophiactis savignyi*, Matsumoto, "A Monograph of Japanese Ophiuridea arranged according to a new classification", Journal of the College of Science, Vol. 38, art. 2, Tokyo, 1917, p. 158.
- Ophiactis savignyi*, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 193; pl. 64, figs. 5, 6; pl. 96, fig. 2.
- Ophiactis savignyi*, Gravely, "Littoral Fauna of Krusadai Island in the Gulf of Manaar", Bull. Madras Govt. Museum (Natural History), N. S., I, 1927, p. 169.
- Ophiactis savignyi*, Clark, A. H., "Echinoderms from the Marshall Islands", Proc. United States National Museum, Vol. 102, 1952, p. 292.

This is a somewhat small species of brittle star, of a mottled, dark greenish colour (in alcohol), common in the littoral zone at Krusadai Island and Pamban in the Gulf of Manaar. It usually has six arms, instead of the normal five. Koehler in the reference

cited (*loc. cit.*, 1905, p. 27) has recorded that among the specimens of this species collected by the Siboga Expedition, eleven had five arms, but many more specimens (about twenty-four) had six arms. The six-armed condition thus appears to be more common in this species than the normal five-armed condition.

There are six to seven short, thick, blunt, rough arm spines. The spines on the sides of the arms are of moderate size. The young ones usually have six arms. The back of the disc is covered with very small scales. There are commonly two mouth papillae on each side, rarely more.

The radial shields are large, scarcely diverging, nearly or quite touching and close together so that only one simple row of scales are found between them. The scales extend only up to the margin of the disc. The side mouth shields are small, rhomboidal with rounded corners, and nearly or quite meeting at their outer ends, and near them are found large triangular pieces. The shields on the back of the arms (upper arm plates) are elliptical, twice as broad as long, microscopically tuberculous, swollen, and usually with a faint lobe on the edge. Numerous disc spines are present. The oral shields are quadrangular (4-cornered), with stumpy corners, and slightly longer than broad. Seven short, thick, blunt spines are present on every lateral shield along the path of the arm. Two scales are present at the tentacle pore.

This species has been collected from Krusadai Island and Pamban, in the Gulf of Mannar, and has, in addition, been recorded from Pulli Island adjacent to Krusadai Island, in the Gulf of Mannar, in 1928 (in sponge). This is a widely distributed species and is referred to by Hyman in her volume on the Echinodermata (Invertebrata, Vol. IV).

The bibliography on this species is very extensive, and has been cited in detail by Lyman in 1882 (Report of the Challenger Expedition, "Ophiuroidea", p. 115, and by Ludwig (Echinodermen des Sansibargebietes, p. 545).

Koeher (*loc. cit.*, 1922), commenting on the Philippine specimens, of this species, Lyman in considering *Ophiactis Savignyi*, *O. sexradiata* and *O. Reinhardtii*, etc., as synonymous terms; but by virtue of the law of priority, it is the name of *Ophiactis savignyi* that must be adopted as the accepted name.

Colour.—The radial shields of the disc are dark with light coloured patches near the arms. On the arms, there are dark, scattered spots here and there. On the aboral margin of every shield are found three white spots which become more prominent and clearer in the darker areas or patches. This is more or less the colour in the living condition. The colour of preserved specimens in spirit, however, is dark greenish, mottled with darker patches.

Specimens in the collection.—Numerous specimens are represented in the Museum's Reference Collection. They are found in two lots, as follows:—

(i) Several specimens from Pamban, Pulli Island and Krusadai Island in the Gulf of Mannar.

(ii) Several specimens specifically collected from Sandy Point, Krusadai Island.

The specimens are all somewhat small, greenish grey in spirit, with darker green broad transverse bands or squarish or circular patches across the upper (aboral) surface of the arms. The under side (oral side) is very pale, almost whitish, or pale whitish cream-coloured. The arms are typically six in number, instead of the normal five. The arms are rather narrow and slender and have somewhat pointed tips. The spines on the sides of the arms are fairly numerous, close-set, regularly arranged and are of moderate size. The mouth is small and presents a star-shaped appearance with six short radiating slits corresponding to the six arms. The upper surface of the disc bears radiating double shields at the bases of the arms. The centre of the disc (upper side) is somewhat granular.

Measurements: (of an average specimen):

Diameter of the disc: 4 mm.

Length of each arm: 12 to 15 mm.

The specimens are common on Krusadai Island and Pamban, in the Gulf of Manner, and sometimes found in plentiful numbers at Sandy Point and on Pulli Island as a commensal on sponges.

Family OPHIOTHRICIDAE.

The scales of the disk are more or less concealed by little spines or tubercles. There are large radial shields and well developed aboral and oral arm shields. Oral papillae are wanting, but a cluster of tooth papillae occurs on the jaw apex. The arms are spiny, the spines being mostly long, thorny and of a glassy appearance, especially in *Ophiotrix*, which is the largest genus of the family.

This is a large family including mostly tropical Ophiuroids which often live as commensals, attached to sponges, gorgonians and other similar marine creatures.

Three genera of this family are represented in the Museum Collection, namely, *Ophiotrix*, *Ophiothela* and *Ophiocnemis*, the first by four species (of which only one, *Ophiotrix hirsuta* has been mentioned in the previous Bulletin of this Museum on the Littoral Fauna Krusadai Island), and the second and third genera by one species each.

These genera may be distinguished as follows:

- | | |
|---|---------------------|
| 1. Disk covered with thorny granules, and very short spines, crowned with thorns at the sides and tips. Arm spines numerous, flattened, long, more or less glossy and thorny .. | <i>Ophiotrix.</i> |
| — Disk covered by very large, naked, radial shields and a few irregular scales or minute plates bearing numerous granules. Arm spines not as above, generally shorter, rounded and not glossy | 2. |
| 2. Disk bearing a few irregular scales in addition to the large, naked, radial shields. Arm spines thorny, clubbed and very short, borne on pad-like side arm-plates | <i>Ophiothela.</i> |
| — Disk covered by minute plates (bearing numerous granules), in addition to the large, naked, radial shields. Arm spines numerous, rounded, microscopically fluted | <i>Ophiocnemis.</i> |

Genus *Ophiotrix* Muller and Troschel.

The disk is set with thorny grains, very short, and the spines are crowned with thorns at the sides and top. The radial shields are in the form of large, triangular swellings, each bounded on its two inner sides by ridges in the skin of the dorsal side. Numerous crowded tooth papillae are present, forming a vertical oval. Teeth are present, but mouth papillae are wanting. The spines are numerous (five to ten to each plate, and often three times as long as the joints), flattened, more or less glossy, thorny, having a central shaft with slender side-spurs springing from it. A small, spine-like tentacle-scale is present. The base of the jaw is pierced by a hole due to the lack of perfect union between the two pieces of the mouth frames. The interbranchial spaces are swelled out to form lobes. Two genital openings are present, beginning outside the mouth shields. The outer arm joints bear hooks.

Contrasted with the rather loose and feeble scaling, are the very large, three-sided radial shields, with projecting knobs at their outer ends, where they are articulated with the clubbed knobby heads of the long, stout, rounded and slightly curved genital plates. To the genital plates is attached a large, almost semicircular genital scale which is connected to the mouth shield by an additional scale. The heads of the genital plates

nearly meet over the top of the arm which is composed of peculiar arm bones. The joints are interlocked effectively in a ball-and-socket fashion which provides a fulcrum for the powerful muscular action involved in the rapid whip-like movement of the arms in *Ophiothrix*.

The jaws are very high, but not long. Their height gives room for the great vertical oval of tooth papillae and the numerous, but shorter teeth.

Four species are represented in the Museum Collection, of which *Ophiothrix hirsuta* is the commonest and most widely distributed species and which is the only one of this genus that has been previously recorded from the Pamban area.

These four species may be distinguished as follows :—

1. Ratio of the arm to disk is as 9 : 1. Arms long and flat 2.
- Ratio of the arm to disk is either 5 or 6 : 1 or 15 - 20 : 1 3.
2. Radial shields small and naked. Disk beset with minute thorny stumps *O. aspidota*.
- Radial shields larger, and both radial shields and disk closely beset with thorny stumps, or short spines *O. hirsuta*.
3. Ratio of arm to disk 5 or 6 : 1 *O. koreana*.
- Ratio of arm to disk 15 - 20 : 1 *O. galathea*.

Ophiothrix hirsuta, Muller & Troschel.

FIGURE 88.

- Ophiothrix hirsuta*, Muller and Troschel, System der Asteroidea, 1842, p. 111.
- Ophiothrix cheneyi*, Lyman, Proc. Boston Soc. Nat. Hist., VIII, 1861, p. 84.
- Ophiothrix cheneyi*, Lyman, Ophiuridae and Astrophytonidae, III, Illustrated Catalogue, Mus. Comp. Zoology, Harvard, I, p. 175.
- Ophiothrix hirsuta*, Von Martens, Decken's Reise in Ostafrika, Bd. III, 1869, p. 125.
- Ophiothrix hirsuta*, Von Martens, Die Ophiuriden des Indischen Oceans, Arch. f. Naturg., Bd. XXXVI, 1870, p. 254.
- Ophiothrix hirsuta*, Lyman, Report of the "Challenger" Ophiuroidea, 1882, pp. 214, 217, 218, 226, 312 and 325.
- Ophiothrix hirsuta*, Marktanner-Turneretscher, Beschreibung neuer Ophiuriden und Bemerkungen zu bekannten, Ann. K. K. Naturhist. Hofmuseums Bd. II, 1887, p. 311, Taf. xiii, figs. 34 and 35.
- Ophiothrix variabilis*, Duncan, "On the Ophiuridae of the Mergui Archipelago", Journ. Linn. Soc. Zool., XXI, 1886, p. 99, pl. ix, figs. 18-19. pl. xi, figs. 32-36.
- Ophiothrix hirsuta*, Preffer, Ostafrikanische Echiniden, Asteriden and Ophiuriden, Mith. Nat. Mus. Hamburg, Bd. XIII, 1893, p. 48.
- Ophiothrix hirsuta*, Ludwig, Echinodermen des Sansibargebietes, Abh. Senckenberg Naturf. Gesells., Bd., XXI, 1899, Heft 4, p. 549.
- Ophiothrix hirsuta*, Koehler, Siboga-Expeditie, Ophiures Littorales, 1905, p. 93.

- Ophiothrix hirsuta*, Koehler, R., "Revision des Ophiures du Museum d'histoire Naturelle, Bulletin Scientifique, Vol. 44, 1907, p. 338.
- Ophiothrix hirsuta*, Koehler, R., "Ophiuroidea", in Fauna Sudwest Australiens, Vol. 1, Lief. 4, Jena, 1907, p. 252.
- Ophiothrix hirsuta*, Mac Intosh, Donald, C., "The Marine Fauna of the Mergui Archipelago, The Ophiuroidea". Edinburgh Proc. Roy. Phys. Soc., Vol. 18, 1911, p. 93.
- Ophiothrix hirsuta*, Clark, H. L., Catalogue of Recent Ophiurans, Mem. Mus. Comp. Zool., Vol. 25, No. 4, Cambridge, 1915, p. 272.
- Ophiothrix hirsuta*, Matsumoto, "A Monograph of Japanese Ophiuroidea, arranged according to a new classification", Journal of the College of Science, Vol. 38, art. 2, Tokyo, 1917, p. 225.
- Ophiothrix hirsuta*, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 234, pl. 31, figs. 1, 2; pl. 33, fig. 13; pl. 92, fig. 2.
- Ophiothrix hirsuta*, Gravely, "Littoral Fauna of Krusadai Island" in the Gulf of Mannar", Bull. Madras Government Museum, (Natural History), N. S., I, No. 1, 1927, p. 170.

The arms are very long and flat, slender, about 9 or 10 times as long as the diameter of the disc. (Arm to disc. : 9:1 or 10:1). Both disk and radial shields are closely beset with thorny stumps or short spines. This species has a thick disc skin set with small, separated scales, each bearing a thorn or spine. The disc is covered with very fine short hair — which can be recognized only under a magnifying lens — and which, in the area of the radial shields are replaced by granules or short, small, cylindrical bodies. Thus mouth shields are broader than long, and three-cornered.

In each interbrachial space, there are about eight to fourteen radiating rows of scales. The disc covering above consists of thorny stumps which lengthen below into short spines.

The genital clefts are separated behind the mouth shields, only by a narrow bridge, which are formed into diverging shelf-like ledges. The shields on the oral side of the arms are very slightly longer than broad, at the sides with rounded angles, and on the aboral margin slightly emarginated.

The shields of the back are very broad, with convex, aboral margin and lateral angles. The spines are in ten rows, of which the lowest are very small, and the appearmost row is also small. The longest are two or three times as long as the breadth of the back shields.

The specimens are generally bluish grey in colour (in alcohol).

The young specimens of this species have the radial shields proportionately larger and more nearly approaching in the interbrachial spaces.

Koehler (*loc. cit.*, 1905), commenting on the Siboga Expedition specimens, adds a few general remarks on this species.

The dorsal brachial plates are very much widened transversely; their distal border meets the lateral sides at sufficiently open angles, ordinarily rounded, but never sharp nor pointed. The surface of the plates is granulose. The spines are numerous, always more than six in number. They are transparent, vitreous (or glassy) and finely serrated throughout their length or on their greater part. The ante-penultimate dorsal plate has sometimes a tendency to widen slightly towards the extremity.

Dr. Gravely (*loc. cit.*), recording this species from Pamban. (Gulf of Manaar) in the previous Bulletin of this Museum on the Littoral Fauna of Krusadai Island (1927) states that the colour of these specimens in spirit is a bluish grey. The arms are long and slender, about nine times as long as the diameter of the disk and their sides are thickly covered with long, slender, glassy, finely serrate spines.

Koehler (*loc. cit.*, 1922), commenting on the Philippine specimens, of this species, reports that there is considerable variation in this species.

The general colour of the specimen in alcohol is grey; the radial shields are lighter, with small blue spot. a series of small blue spots runs along the distal border of each upper arm plate. The radial shields show only small and closely crowded granules which leave naked a considerable part of their surface. The upper arm plates are typical in most specimens.

Koehler reports that in a specimen examined by him from the Red Sea, the radial shields are very much more extensively covered with granules than in the Philippine specimens.

The club spines of the dorsal surface of the disk in this species are usually thick and stout and conical in form and they terminate in thick points which vary from four to six number. At some distance from the disk, the first ventral arm spine is transformed into a hook with three or four branches of the form which most commonly seen in the genus *Ophiothrix*, that is to say, with the terminal point very stout, the second much weaker, and the third or the following two still weaker. This form is different from what occurs in *Ophiothrix galathea*. The rounded or oval tentacle scale ends in a point.

Ophiothrix hirsuta is a very widely distributed species found throughout the whole of the Indo-Pacific Region.

Specimens in the collection.—This species is very common at Pamban in the Gulf of Manaar and several specimens have been collected at Pamban. A few wet-preserved specimens of this species are represented in the Museum's Reference Collection, of which one was collected at Shingle Island and one at Krusadai Island, and the rest from Pamban Bridge at Pamban, in the Gulf of Manaar. These last specimens were collected in September, 1948.

(1) One specimen. Locality: Shingle Island, in the Gulf of Manaar.

The specimen is bluish grey in colour (in alcohol), the arms bearing distinct, dark purplish brown cross bars. The arms are long and slender, about nine times as long as the diameter of the disk. The sides of the arms are thickly beset with long, slender, somewhat translucent, whitish spines, darkened at their tips and finely serrate. The disk is covered with coarse, thorny granulations and each interbranchial space bears eight to fourteen radiating rows of scales.

Measurements: Length of the arm: 80 mm.

Diameter of the disk: 9 mm.

(2) One specimen, wet-preserved. Locality: Krusadai Island, in the Gulf of Manaar.

The specimen is dark bluish grey in spirit. The arms are long, slender and somewhat flattened. The top of the disk is traversed by raised, radiating ridges. The surface of the disk is covered with thorny granulations. Two of the arms are broken in this specimen, one of the arms being broken off almost at the place where it joins the disk.

Measurements: Length of the arm: 98 mm.

Diameter of the disk: 11 mm.

(3) Six specimens, wet-preserved. Locality: Pamban Bridge, Pamban, in the Gulf of Manaar (September, 1948).

The specimens are rather fragile and some of them are in a rather badly mutilated condition with the arms detached from the disc. The disc and arms are dark purplish or blackish brown, while the spines at the sides of the arms are slender whitish and glossy.

Measurements: (i) Of the largest specimen in this lot:

Length of the arm: 114 mm.

Diameter of the disc: 16 mm.

(ii) Of a smaller specimen:

Length of the arm: 72 mm.

Diameter of the disc: 9 mm.

Ophiothrix (?) koreana Duncan.

FIGURES 89 AND 90.

Ophiothrix koreana, Duncan, "On some Ophiuroidea from Korean States", Journ. Linnaean Society, Zoology, XIV, 1878, p. 473; pl. ii, figs. 28—32.

Ophiothrix koreana, Lyman, "Challenger Reports", Ophiuroidea, Zoology, V, 1882, p. 216 and p. 226.

Ophiothrix koreana, Marktanner-Turneretscher, G. Beschreibungen neuer Ophiuriden, Ann. k.k. nat. Hof museums, Wien., Vol. 9, 1887, p. 308.

Ophiothrix koreana, Clark H.L., "North Pacific Ophiurans in the Collection of the United States National Museum", Bull. United States National Museum, No. 75, 1911, p. 257; figs. 127 and 128.

Ophiothrix koreana, Clark H.L., "Catalogue of Recent Ophiurans", Mem. Mus. Comp. Zool., Vol. XXV, No. 4, Cambridge, 1915 p. 273.

Ophiothrix koreana, Matsumoto, "A Monograph of Japanese Ophiuroidea, arranged according to a new classification", Journal of the College of Science, Vol. 38, art. 2, Tokyo, 1917, p. 220.

Ophiothrix koreana, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 242, pl. 45, figs. 1—6; pl. 99, figs. 4.

This species has been originally recorded from the Korean States at a depth of 2 to 3 fathoms by Duncan (*loc. cit.*, 1878) who first described it as a new species.

The species comes under the following grouping in Lyman's arrangement (*loc. cit.*, 1882).

"Arms five to six times the diameter of the disk. Radial shields essentially naked. A slight, re-entering curve is present in the outside of the under arm plate".

The disk is usually circular in outline and rarely pentagonal; it is rather thick, flat above, and swollen at the interbrachial spaces. The radial shields are longer than broad, narrow and rounded within, and broad without, where there is a short projection over the arm. They are more closely set outside than within, and are often slightly

separated by dermal tissue. Their outer margins are sunken, as it were, and rounded, and their surface is covered with a skin which supports a very few stumps, which may nearly be covered by them, and which may have spinelets and even a short spine or two upon the surface. The stumps are swollen at the base, constricted in the cylindrical portion and are armed with three sharp, slender, widely spaced thorns. The thorns are rarely two and four in number. The spinules are longer than the stump, and have longer thorns. The spines are glassy, slender and toothed at the side.

The rest of the upper surface of the disk is crowded with stumps, resembling those of the radial shields. There are spines and spinules in some specimens, near the centre.

Towards, and on, the interbrachial spaces, reaching in a triangular patch on to the under surface, are spinules, which become crowded inferiorly. They are slender with swollen bases of attachment, and have long, trifid thorns.

In the living condition, there is a reddish tint on the centre and in the inter-radial spaces, and it also sometimes encircles the whole disk as with a narrow band. The tips of the stumps and spinules are often red. The disk is covered with a skin, under which traces of scales may sometimes be seen.

The mouth shields are small, broader than long, diamond-shaped rounded at the sides, angular within and surved without. The oral edges are slightly re-enteringly curved. The madreporic shield is elliptical and large.

The side mouth shields are rather large; they are narrow at their inner edge, where they do not unite, and broad and triangular where they are in contact with the first lower arm plate. Their oral edge is curved, with the concavity towards the jaws.

The pairs of jaws are slender and are widely separate, and each jaw of the separate angle is distinct near the mouth shield.

The tooth papillae are in a very long, narrow oval; they are small, and crowded in a row of six or more inferiorly and become gradually larger above until they approach the true teeth. Within the edge of the oval thus formed there is a well separated mass of tooth papillae in two rows, and they are larger than those around. The number of papillae is variable.

The teeth are narrow, flat, slightly rounded, and sometimes have a boss on the free end; they increase in size upwards, but the highest is sometimes smaller than the others. There are five in all.

The lower arm plates are typically slightly broader than long, broader without than within, with sides sloping inwards. The lower arm plates increase in size from the oral ring to where the arm is well free from the disk, and they retain a considerable dimension until the terminal third, where they decrease gradually. The plates are rather separate and united by skin, and they are rather flat and form the bulk of the under surface. At the tip of the arm the plates are longer, less incised, and are closer together.

The upper arm plates are close, longer than broad, angular orally, with a straight edge there, and they are boldly rounded distally. They slope on either side from a median, faint, central ridge, which ends at the roundel extremity in a faint nodule. The sides slope to the angle and are overlapped by the side arm plates, and one upper arm plate slightly overlaps that next to it. Near the tip, the length of these arm-plates increases over the breadth. A white longitudinal line with a red or purple one on either side, of greater or less breadth, is usually present.

The side arm plates are well developed, and stand out from the arm, forming with the connecting skin much of the side arm. Below, the free edge extends outwards on a level with the surface of the under arm plates, and supports short spines and the small tentacle-scale. Above, the inner end of side arm-plate is prolonged into a short,

angular process with a curved margin, which overlaps, and to a certain extent separates the upper arm plates. This process has one or more long spines on its surface, and the others are on the free edge of the plate, where it forms the side of the arm. The plates extend on the under surface of the arm, but do not meet, and are broad enough to place the tentacle scale well outside. The scale is small, largest at the base, and minutely thorned.

The spines near the disk are numerous and they vary from 9 to 12; further on, they diminish to 7, 5 and 3 in number.

The spine next to the tentacle scale is the smallest, and is a mere spinule, with a sharp thorn on the plates nearest the disk and for some distance, but soon the thorn becomes bent and a second one forms on its side, and there is a boss-like prominence below and near the origin. This two-toothed and curved hook increases in size towards the end of the arm, is glossy and points orally. Sometimes there are three teeth. The next spine is slightly larger, is flat, tapering, serrated and striated, and is often bushy at the broad top, or its top may be sharp. Sometimes the denticles on the side are long enough to simulate hook-processes. The third is slightly larger, and the others increase in length and size, the maximum being reached on the shoulder of the arm, and before the process of the side arm plate is reached. Occasionally on the top of the arm and on the extremity of the side arm plate, there is a smaller, needle-shaped spine without denticulation. The spines, as a whole, are flat, striated, many-toothed and end with a sharp brush of thorns, or are blunt and rarely simple at the termination. All have a distinct, boss-like base, and are glossy when young, and more opaque, when old and dry.

The type locality is Korean Straits. The type of this species was collected in the Korean Straits at a depth of 23 fathoms.

The chief diagnostic characters of *Ophiothrix Koreana* are as follows (according to Lyman):

It is similar to *Ophiothrix spiculata*, that is to say, the disk is beset with thorny stumps and slender spines or with either alone. The arm spines are longer than in *Ophiothrix angulata*. The colour in alcohol is blue, but in life it is reddish or purplish.

But the under arm plates are proportionately longer; and the lowest arm spine keeps the form of a double hook till quite near the base of the arm.

However, as Koehler (*loc. cit.*), states, there is considerable variation in this species, especially in regard to the armature of the dorsal surface of the disk. In all the specimens examined by Koehler, the radial shields are reported to be very large and the large size constitutes one of the specific characters of *Ophiothrix koreana*. The shape of the upper arm plates is also very characteristic the distal angle makes a sort of rounded and slightly projecting beak, and the two sides which bound it are very slightly turned inwardly instead of being straight, or even sometimes convex.

The tentacle scale is not small as Duncan (*loc. cit.*), states in his original description; it is rather large, oval in shape and shows on its distal border sometimes a short, conical point broadened at the base, and sometimes several smaller points.

The general colouration is always roseate; sometimes it passes into a reddish yellow. It is not rare to see a white band extending all along the median dorsal line of the arms, bounded on either side by a red or pink band showing a more or less dark purple spot towards the distal border of each upper arm plate. In some specimens, the upper arm plates show at intervals a large, dark purple spot which occupies a greater part of their surface.

Specimens in the collection.—Three specimens, of which one (from Ravapuram Bay, Chingleput District, is doubtfully referred to this species) are represented in the Museum's Reference Collection.

(1) Two specimens, wet-preserved (in alcohol); Locality: Pamban, in the Gulf of Mannar, 1922.

These are small specimens and are perhaps young ones. These are earthy brown in spirit, the spines on the sides of the arms being whitish and glassy in appearance. The arms are five in number, rather short, being five to six times the diameter of the disk. On the under side, the arms are paler brown, but the interbrachial areas are clearly marked out as distinct, dark brown, circular patches. In the smaller specimen, the arms are very much curled and entwined.

Measurements: (of the larger specimen):

Diameter of the disk: 4 mm.

Length of the arm: 20 mm.

(2) One specimen, labelled *Ophiothrix* sp. seems referable to this species. The specimen is wet-preserved, in alcohol. Locality: Royapuram Bay, Chingleput District.

This is a small specimen, with five arms, and dull creamy brownish in colour. The arms, except one, are all broken. The arms bear distinct, cross bar-like markings of a darker brown colour. The upper surface of the disk bears granules. The centre of the diameters of the disk. The specimen is apparently a young one, and approached *Ophiothrix koreana* in many respects.

Measurements: Diameter of the disk: 5 mm.

Length of the arm: 22 mm.

Ophiothrix aspidota Muller & Troschel.

FIGURES 91 AND 92.

Ophiothrix aspidota, Muller and Troschel, System Asteriden, 1842, p. 114.

Ophiothrix aspidota, Lyman, "Ophiuridae and Astrophytidae, old and new", Bull. Mus. Comp. Zoology, Harvard, Vol. III, No. 10, Cambridge, 1874, p. 234.

Ophiothrix aspidota, Lyman, Challenger" Reports, Ophiuroidea, Zoology, Vol. V. 1882 p. 87, fig. 50—54.

Ophiothrix aspidota, Koehler, R., "Ophiures nouvelles ou peu connues", Mem. Soc. Zoologique de France, Vol. XXVII, 1904, pl. 21, and P. 227.

Ophiothrix aspidota, Clark, H.L., "Catalogue of Recent Ophiurans", Mem. Mus. Comp. Zoology, Harvard, Volume XXV, No. 4, Cambridge, 1915, p. 269.

Ophiothrix aspidota, Koehler R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922 p. 209 pl. 32, figs. 1—5; pl. 33, fig. 7; pl. 97, fig. 3.

The disk is granulated. The radial shields are smooth and the mouth shields are small, broader than long. The shields of the oral side of the arms are four-cornered.

The back shields of the arms are without a keel or wedge, and with a slightly convex aboral margin and without a pointed tip. The spines are arranged in eight to nine rows, and are flat and soft, the longest being twice as long as the breadth of the back shields of the arms; the lowermost spines are very small and increase gradually in size; the upper ones are as big as the lateral ones.

This species, as well as the next one, *Ophiothrix galathea*, are included under the following grouping according to Lyman's arrangement based on their key characters (Lyman, *loc. cit.*, 1882):

"Radial shields naked. The arms are long and flat; the arms as compared with the disk are as 9 — 20 : 1".

The diagnostic characters of *Ophiothrix aspidota* are summed up by Lyman as follows:

"Arm to disk 9 : 1. Radial shields small. The disk is beset with minute thorny stumps. The under arm plates are much wider than long, with rounded corners." But there is considerable variation and in some specimens the radial shields are large.

The arms are flattened and remain of the same width over a very large part of their length.

The club spines of the dorsal surface of the disk are short, rather broad, and normally terminate in three subequal; sometimes these spinules are four in number or two only. Toward the borders of the disk, the club spines become a little longer and more slender. The first ventral arm spine becomes transformed rather rapidly into a hook which never becomes very large, and which may show as many as eight or nine subequal points of its concave side. The subsequent spines bear very closely crowded and much elongated teeth on their proximal border, while the teeth are short conical and few on the distal border. The tentacle scale is elongated and ends in a sharp point.

The general colour of the specimens during life is light pink; the dorsal surface of the disk is light-coloured; the arms are a little darker and show slightly darker annulations. On the ventral surface the disk is light grey and the arms are pinkish grey, with traces of annulations and a darker spot toward the middle of each of the under arm plates. The spines are colourless. Some dark purple dots are found on the radial shields and on the upper arm plates at the base of the arms. There is no trace of a dorsal median line along the arms. Some specimens are violet grey during life and the spines are sometimes greyish.

Describing a specimen of this species collected by the Albatross Expedition, in the United States National Museum Collection, Koehler (*loc. cit.*, 1922), states that the radial shields are large, absolutely naked, and their surface is very finely granulose. The granulation of the upper arm plates is scarcely marked. The arm plates are trapezoidal in shape with the distal border almost straight, and the lateral angles are very sharp. The adoral plates are widely removed from the median inter-radial line and they show an irregularly rounded principal portion continuing by a slender process which separates the mouth shield from the first side arm plate.

The under arm plates in larger specimens are distinctly broader than long, while in smaller specimens, they are almost squarish and as long as broad with the distal border very slightly rounded.

Muller and Troschel's (*loc. cit.*), original type specimen is reported to have been collected from the East Indies. Lyman has recorded it from Celebes. This species has also been recorded from Madagascar, from Ceylon and from Karachi. The specimen in the Madras Museum collection which is from Krusadai Island, appears to be the first record of this species from the East Coast of South India.

Specimens in the collection.—One specimen, wet-preserved (in alcohol). Locality: Krusadai Island, Gulf of Manaar, 1922.

The specimen is fairly large, dark purplish brown in spirit. The arms are very long in proportion to the disk and somewhat flattened and distinctly cross-barred with dark markings. The arms bear spines which are long, slender, pointed and darkened at their tips and closely crowded. The upper surface of the disk bears small, close-set granules (minute thorny stumps) and strong, elevated, radiating ridges separated by deep furrows. The arms are five in number.

In this particular specimen, one arm has been lost. The length of the arm is about 9 times the diameter of the disk. On the under side, the genital pouches are seen clearly as large, blackish, rounded structures in each of the five inter-brachial spaces.

Measurements: Diameter of the disk: 15 mm.

Length of the arm: 135 mm.

Ophiothrix galathea Lutken.

FIGURES 93 AND 94.

- Ophiothrix galathea*, Lutken, *Ophiuriderum novarum descriptiones nonnullae*, Overs. K. danske Vidensk. Selsk. Forh., 1872, p. 90 and p. 108.
- Ophiothrix galathea*, Lyman, "Ophiuridae and Astrophyttidae of the Challenger of Expedition", Bull. Mus. Comp. Zool. Harvard, VI, 1879, p. 54.
- Ophiothrix galathea*, Lyman, "Challenger Reports", Ophiuroidea, Zoology, Vol. V, 1882, pp. 217, 227, 312 and 325.
- Ophiothrix galathea*, Bell, J., "Echinodermata" in Reports of the Zoological Collections of "Alert", 1884, p. 142.
- Ophiothrix galathea*, Marktanner—Turneretscher, Beschreibung neuer Ophiuriden und Bemerkungen zu bekannten, Ann. K.K. nat. Hofmuseums, Bd. 11, 1887, p. 309.
- Ophiothrix galathea*, Bell J., "Echinoderms from Tuticorin" Proc. Zool. Soc. London 1888, p. 388.
- Ophiothrix galathea*, Brock, Die Ophiuridenfauna des Indischen Archipels, Zeit. f. wiss. Zool. Bd. XLVII, 1888, p. 517.
- Ophiothrix galathea*, Lorient, P. de, Echinodermes de la baie d'Amboine, Rev. Suisse de Zool., Vol. I, 1893, p. 420.
- Ophiothrix galathea*, Koehler, R., Siboga-Expeditie, Ophiures Littorales, 1905, p. 84.
- Ophiothrix galathea*, Koehler, R., Echinides, Stellerides et Ophiures recueillies par M.M. Bonnier et Perez dans lamer Rouge (cotes d'Arabie), Bulletin du Museum, Paris, 1905, p. 458.
- Ophiothrix galathea*, Koehler, R., "Revision des Ophiures du Museum d'Histoire Naturelle", Bull. Scientifique Vol. 44, 1907, p. 333.
- Ophiothrix galathea*, Koehler, R., Asteries et Ophiures des iles Aru et Kei, Abh. Senckenberg. Naturf. Gesells., Vol. 33, 1910, p. 294.
- Ophiothrix galathea*, Koehler, R., Bull. Muséé Oceanographique, No. 311, Monaco, 1915 p. 272.
- Ophiothrix galathea*, Koehler, R., "Ophiurans" of the Philippine and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 233.

This species is included in the group of Ophiuroids showing the following characteristic features according to Lyman's arrangement;

"Radial shields naked. Arms long and flat, and, as compared with the disk, 9 — 10 : 1".

The diagnostic features of *Ophiothrix galathea* are as follows:—

The proportion of the arm to the disk is as 9 : 1. The radial shields are small. The disk is beset with minute thorny stumps. The under arm plates are much wider than long, with rounded corners.

The radial shields bear a few scattered granules in some specimens, but are absolutely naked in others, showing only small, blue dots. Sometimes the radial shields are large and the two shields of each pair are very close together with their internal borders straight. Usually the granules which cover the dorsal surface of the disk in the inter-radial spaces are short and conical with three or four short and blunt points as usual, but may be occasionally unusually elongated, forming true spines, with rather elongated points.

The arm spines are well developed; on the first arm segment, the first ventral spine which is thick and strong, shows a few processes which end in sharp points. It is only at some distance from the disk that these points develop further, while the dimensions of the spine become somewhat reduced. Further on, when the transformation into a hook is complete, this first spine is also greatly reduced in size and usually shows four elongated, rather well spaced out points; the terminal point which forms the extremity of the hook, is a little stouter than the three others, which remain subequal. The tentacle scale is large and rounded, and bears on its free border a few conical and subequal points.

This species is widely distributed in the Indo-Pacific Region and has been collected from numerous localities in this region, including Tuticorin and Pamban on the coasts of South India.

Specimens in the collection.—There are several specimens collected from Pamban, in the Gulf of Manaar, in 1922, contained in the Museum's Reference Collection, but they are all in a very bad state of preservation and in a fragmentary condition, with extremely brittle arms, which have broken up.

The arms are flat and very long, about 15 to 20 times the diameter of the disk. The upper surface of the disk is covered with close-set, thorny granules. The spines at the sides of the arms are slender, long, translucent white and close-set. The specimens are bluish grey or greyish brown (in alcohol), the disk being darker, almost blackish brown.

Measurements: (i) of a larger specimen in which all the arms have been broken into bits; *Locality:* Pamban, Gulf of Manaar: *Diameter of the disk:* 16 mm.

(ii) Of a smaller specimen (also from Pamban): *Diameter of the disk:* 6 mm. *Length of the arm:* 90 mm.

Genus *Ophiothela* Verrill.

The disk is covered by very large, naked radial shields and a few irregular scales. Numerous crowded tooth papillae are present, forming an irregular, vertical oval. Teeth are present, but mouth papillae are wanting. The arm spines are thorny, clubbed and very short, borne on pad-like side arm plates, which stand out free from the arm. The upper arm plates are broken in irregular pieces, or represented by several wart-like swellings. The base of the jaw is pierced by a vertical hole. The interbrachial spaces are somewhat swollen. Two large genital openings are present, beginning outside the mouth shields. The skeleton is like that of *Ophiothrix*.

A single species, *Ophiothela danae*, is represented in the Museum collection, and has been collected both from the Madras beach and from the Pamban area in the Gulf of Manaar.

Ophiothela danae Verrill.

FIGURE 95.

- Ophiothela danae*, Verrill, Proc. Boston Soc., Nat Hist., XII, 1869, p. 391.
- Ophiothela danae*, Lyman, "Challenger" Reports, Ophiuroidea, Zoology, V., 1882, pp. 230, 312, and 326.
- Ophiothela danae*, Marktanner-Turneretscher, 1887, Beschreibung neuer Ophiuriden and Bemerkungen zu bekannten. Ann. K.K. Naturhist. Hofmuseums, Bd. II, 1887, p. 133.
- Ophiothela danae*, Döderlein, Bericht über die von SEMON gesammelten Ophiuroidea in SEMON, Zool. Forschungereisen, Bd. V, 1897, p. 297, pl. xvii, figs. 25, 25 a and 25 b.
- Ophiothela danae*, Koehler, R., Echinodermes recueillis par l' Investigator dans l' Ocean Indian. Les Ophiures littorales, Bull. Scientif., Vol. XXXI, 1898, p. 88.
- Ophiothela danae*, var. *involuta*, Koehler, R., 1898, *Ibid.*, p. 88.
- Ophiothela danae*, Döderlein, Über einige epizoisch lebende Ophiuroidea, in SEMON, Zool. Forschungereisen, Bd. V, 1900, p. 486, pl. xxxvii, figs. 3, 3 c.
- Ophiothela danae*, Koehler, R., Siboga Expeditie, Ophiures littorales, 1905, p. 117.
- Ophiothela danae*, Koehler, R., Echinides Stellerides et Ophiures recueillies par MM. Bonier et Perez dans la mer Rouge (cotes d' Arabie), Bull. du Museum, Paris, 1905, p. 458.
- Ophiothela danae*, Koehler, R., Revision des Ophiures du Museum d' Histoire naturelle, Bull. Scientif., Vol. 44, 1907, p. 340.
- Ophiothela danae*, Koehler, R., Ophiuroidea, in Fauna Sudwest Australiens, Vol. I, Lief 4, Jena, 1907, p. 253.
- Ophiothela danae*, Clark, H.L., "Catalogue of Recent Ophiurans" Mem. Mus. Comp. Zool., Vol. 25, No. 4, Cambridge, 1915, p. 284.
- Ophiothela danae*, Matsumoto, "A Monograph of the Japanese Ophiuroidea, arranged according to a new classification", Journal of the College of Science, Vol. 38, Art. 2, Tokyo, 1917, p. 831.
- Ophiothela danae*, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 297, pl. 59, figs. 1, 2 and 3; pl. 103, fig. 1.
- Ophiithela danae*, Gravely, Bull. Madras Govt. Museum, (Natural History), "Shells and other Animal Remains of the Madras Beach", Part I, 1940, p. 87.

This species has been recorded along the East Coast of South India from the Madras Harbour. It is a smaller species than the next one (*Ophiocnemis marmorata*) which also occurs in the Madras Harbour, and has six arms. In the Madras area, it lives in the Madras Harbour and is common among oysters, etc., attached to piers (Gravely, loc. cit., 1940).

The radial shields are large, and the interbrachial spaces are very narrow and smooth or set with a few grains. There are six arms, the upper surface of which is sparsely granulated.

The dorsal surface of the disk bears numerous large tubercles. On the dorsal surface of the arms, may be distinguished the transverse tubercles, larger than the others, which were specially noted by Loriol.

The general colouration is pinkish grey, with dark blue striae on the dorsal surface of the disk and on the arms. Sometimes there is marked colour variation and the dorsal surface of the disk is rather dark blue and the ventral surface grey; the dorsal surface of the disk shows wavy striae with some dark blue spots which are sometimes very numerous. Occasionally the tubercles on the dorsal surface of the disk are very feebly developed, and these tubercles scarcely appear except towards the periphery of the disk; on the arms also these tubercles may be relatively less numerous than in normal specimens, but the transverse tubercles of each segment is more marked while the others are smaller and less numerous. These smaller tubercles may occur only on the first arm segments and may disappear rapidly so that the large transverse tubercle alone persists in the later segments.

This species is rather widely distributed in the Indo-Pacific Region. It has been recorded from Fiji Islands and from the Philippines, besides Madras, and Matsumoto (*loc. cit.*), has recorded this species from various localities in Japan.

Specimens in the collection.—Numerous small specimens collected from the Madras Harbour are represented in the Museum's Reference collection. The specimens are yellowish brown or pale creamy yellow in spirit. The arms are all curled at their tips. There are six arms. The upper surfaces of the arms are sparsely granulated. The interbrachial spaces are narrow. The disk is covered by large, naked, radial shields. The spines on the sides of the arms are rather short and thick and not too closely set. The arms are comparatively short in this species in proportion to the diameter of the disk.

Measurements: Diameter of the disk: 3 mm.

Length of the arm: 9 mm.

Genus *Ophiocnemis* Muller & Troschel.

The disk is covered by very large, naked radial shields and minute plates bearing numerous grains. On the interbrachial spaces below, a fine scaling is present. Numerous crowded tooth papillae are present forming a vertical oval. Teeth are present, but there are no mouth papillae. The arm spines are numerous, rounded, microscopically fluted, not translucent, a little hollow in the centre. The base of the jaw is pierced with a vertical hole. The interbrachial spaces are somewhat swollen. Two large genital openings are present, beginning outside the mouth shields. Four genital clefts are present in every inter-radius (inter-brachial space), two side by side on each side. The mouth cleft is naked without papillae.

The skeleton belongs strictly to the group of *Ophiothrix* with its peculiarities exaggerated. Thus the special apophysis extending outward from the outer surface of the arm bones is larger and more spreading so that it really is locked into the slot in the following bone. The upper surface of the arm bones is, moreover, larger and together with the margin, is deeply grooved. In general appearance the genital plate is like that in *Ophiothrix* and its scale also has a correspondingly similar shape.

A single species, *Ophiocnemis marmorata*, is represented in the Museum collection.

Ophiocnemis marmorata Muller & Troschel.

FIGURES 96 AND 97.

- Ophiocnemis marmorata*, Muller and Troschel, System Asteriden, 1842, p. 87, pl. xlii, figs. 14 and 15.
- Ophiocnemis marmorata*, Lyman, "Ophiuridae and Astrophytidea, old and new", Bull. Mus. Comp. Zool., III, No. 10, 1874, Cambridge, p. 234.
- Ophiocnemis marmorata*, Lamarck, Hist. Anim. sans vert., II 1816, p. 543.
- Ophiocnemis clypeata*, (young), Ljungmann, 1866, Ophiuroidea Viventia, Ofvers Kong. Akad. Forh., XXIII, 1866, p. 163.
- Ophiocnemis marmorata*, Duncan, "On the Ophiuroidea of the Mergui Archipelago", Journ. Linn. Soc. Zool., XXI, 1887, p. 103.
- Ophiocnemis marmorata*, Döderlein, Echinodermen von Ceylon, Zool. Jahrbucher, Bd. III, 1888, pl. xxxi, figs. 1 and 2.
- Ophiocnemis marmorata*, Koehler, Echinodermes recueillies par "l' Investigator", Les Ophiures Littorales, Bull. Scientifique, Vol XXXI, 1898, p. 84.
- Ophiocnemis marmorata*, Ludwig, Echinodermen des Sansibargebietes, Abh. Senckenberg Naturf. Ges. Bd. XXI, 1899, p. 550.
- Ophiocnemis marmorata*, Lorient, P. de, Notes pour servir l'étude des Echinodermes, VIII, Revenue Suisse de Zoologie, Vol. VIII, 1900, p. 84.
- Ophiocnemis marmorata*, Lyman, "Challenger" Reports, Zoology, V, Ophiuroidea, 1882, pp. 229, 312 and 326; pl. XLII, figs. 14 and 15.
- Ophiocnemis marmorata*, Koehler, R., Siboga Expeditie, Ophiure. Littorales, 1905, p. 112.
- Ophiocnemis marmorata*, Koehler, R., Revision des Ophiures du Museum d' Histoire Naturelle, Bull. Scientifique, Vol. 44, 1907, p. 339.
- Ophiocnemis marmorata*, Mac Intosh, "The Marine Fauna of the Mergui Archipelago, The Ophiuroidea", Edin. Proc. Roy. Phys. Soc., XVIII, 1911, p. 166.
- Ophiocnemis marmorata*, Clark, H.L., "Catalogue of Recent Ophiurans", Mem. Mus. Comp. Zool., XXV, No. 4, Cambridge, 1915, p. 283.
- Ophiocnemis marmorata*, Clark, H.L., "The Echinoderms of Ceylon other than Holothurians", Spolia Zeylanica, Vol. X, part 37, 1915, p. 90.
- Ophiocnemis marmorata*, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 296.
- Ophiocnemis marmorata*, Gravely, "Shells and Other Animal Remains of the Madras Beach", Bull. Madras Govt. Museum (Natural History), V, No. 1, 1941, p. 86, fig. 29, No. 2.

The genus *Ophiocnemis* was insufficiently diagnosed by Muller and Troschel, but Lyman (loc. cit.), has furnished an amended definition which is more complete.

Duncan (*loc. cit.*), reporting on the specimens of this species from the Mergui Archipelago, observes that the skin in this species is naked and plain.

There is no original drawing of the type specimen of *Ophiocnemis marmorata* Muller and Troschel, and their original description is also very short. Duncan has observed certain variations in this species and has therefore ventured to suggest a few additional points of detail on this species.

The ratio of the disc to the arms is as 1:6. The mouth shields on the aboral margin are rounded off, and on the adoral margin, are drawn out to a point, near which are two pieces (shields) so that the three shields together form a rounded surface. Teeth papillae are crowded together (very close) without being arranged in rows. One genital cleft lies close to the arm on its side. This cleft is separated from the second cleft on the same side by a calcareous plate. This second genital cleft has on the other margin two calcareous plates — one small, close to the mouth shield and a bigger one on its whole length. The inter-radius is nearly completely naked; only a few short, small spines are present, which form a streak towards the margin. The radial shields are naked and take up nearly all the space on the back of the disk. In between the radial shields are found very narrow bands of very small shields, and on the middle of each are found one or many depressions in which lies a granule. The dorsal shields of the arms are six times as broad as long and have straight aboral margins, which form ridges or keels along the entire length of the arms. In the middle, they are raised in the form of a slightly developed keel. The shields on the oral side of the arms are oval, enlarged in front and behind, more than twice as broad as long. On the lateral shields are found five small spines, of which the top-most is small, the second and third the biggest and the lowermost the smallest.

The nodular stumps on the skin between the radial shields are not on visible scales, and they crowd the interbrachial margin, some being on the outer edge of the radial shield. They also crowd in the centre of the disk. The skin is plain below. The generative scale is large, broad and arched below where it is free. A forked genital process is present on the aboral side of the mouth shield. The side mouth shield is placed orally to the long diameter of the mouth shields (i.e., the diameter from side to side). The first lower arm plate is very small.

Beyond the disk, the lower arm plates are broader than long, incurved orally and aborally, longest at the sides and slightly incurved there. They increase in length towards the tip. The upper arm plates are much broader than long, arched, and semi-keeled near the end of the arm, the edges within and without being either slightly curved or straight.

The tentacular opening is placed well at the side of the arm at about the middle of the length of the arm; a very small tentacle scale is present on the edge of the side arm plate. Usually four spines are present; they are small, cylindro-conical, not sharp, striated, and not hollow, only less dense in the centre, banded with colour, dull white, opaque and microscopically spinulose. The first becomes a glassy, bifid hook at about the level of the middle of the length of the arm; the fourth varies in size, and the third from the lower arm is the longest. The diameter of the disk in a typical adult specimen is about 13 mm. and the length of the arm is about 70 mm.

The specimens during life are generally light-coloured, with grey bands on the arms; in every band, there is an oval lighter-coloured longitudinal marking. The colour in alcohol is generally brownish green, with splashes of white, and dots and lines and splashes of dark green. The radial shields bear white spots and lines. An indefinite ringing is noticeable on the arms above.

Koehler (*loc. cit.*, 1922) has reported a single specimen of this species from the Philippine Seas; it is stated to be a very small specimen, the diameter of its disk measuring only 7 mm.

This species is very widely distributed over the whole of the Indo-Pacific Region; it is known from Zanzibar, Ceylon, the Mergui Archipelago, Singapore, the Sunda Archipelago, and the Coast of north and north-west Australia.

Duncan (*loc. cit.* 1887) reports a young form of this species (diameter of the disc 5 mm.; arms: 15 mm.) which has the nodules on the skin well developed in the inter-radial areas, and there are stumps at the edge of the interbrachium where the skin below commences. There is some minute scaling at the centre of the disk and the nodules are reported to be well seen in this specimen. The upper arm plate is arched from side to side, but the length is greater than the breadth. The hooks commence near the disk.

Duncan (*loc. cit.*, 1887) has recorded this species from Elphinstone Island, Sullivan Island (at a depth of 4 fathoms) and King Island — all in the Mergui Archipelago.

Specimens in the collection.—Three specimens (wet-preserved) are represented in the Museum's Reference Collection. Locality: Madras.

Two of these are in a mutilated condition, one being in a very bad state of preservation.

The specimens are dark bluish grey or steel grey above and pale creamy white or greyish white below. The disk has a more or less pentagonal shape with the interbrachial spaces markedly convexly arched. The upper surface of the disk bears a characteristic 10-armed cross-like pattern of small spines. It is common on the sandy sea bottom around Madras Coast and is sometimes caught in fishermen's nets. The central area of the upper surface of the disk is darker and bears small, close-set, thorny, granular spines. The upper surface of the arms bears a series of small, pale-coloured, widely spaced spots. The spines at the sides of the arms are small, close-set and finely pointed. On the oral side, the arms are almost white.

(1) One of these two (mutilated) specimens is more intact and complete and has only one arm broken off from the disk very close to its attachment to the disk.

Measurements: Diameter of the disk: 15 mm.

Length of the arm: 82 mm.

(2) The other specimen, which is badly mutilated, consists only of the disk with only a portion of one arm attached to it, and with remnants of the arms lying loose in the container (in three pieces). This specimen is much lighter in colour, being pale greyish brown above; the diameter of the disk is 17 mm., but the length of the arms could not be determined as the arms are broken and incomplete.

(3) One specimen from the Madras Harbour, labelled as "Undetermined species" has since been identified as belonging to this species. The specimen is greyish brown in spirit, with the characteristic dark brown cross-bands on the arms. The characteristic ten-armed cross-shaped marking with the central circular dark patch on the upper surface of the disk is distinct. The arms are rather thick, dorso-ventrally flattened. The spines at the sides of the arms are very long, slender, whitish, with slightly brownish tips, and closely crowded. Many of the arms are broken some distance away from the base, as they are extremely brittle.

Measurements: Diameter of the disk: 14 mm.

Length of the arm: 115 mm.

Width of the arm at the base: 5 mm.

Family OPHIICOMIDAE

This family includes relatively large and brightly coloured species of Ophiuroids with spiny arms provided with strong, generally solid spines. The scalation of the disk is completely concealed by granules in the typical genera of this family. Oral papillae are present and merge into a large cluster of tooth papillae that are followed aborally by a few large teeth.

This family is represented in the Museum's collections by a single species, *Ophiocoma scolopendrina*, which is a wide distributed species in shallow, tropical waters in the Indo-Pacific Region, belonging to the main genus of the family, namely, *Ophiocoma*.

Genus *Ophiocoma* Agassiz.

The disk is evenly granulated. The radial shields are covered. The teeth, mouth papillae and very numerous, close-set tooth papillae are arranged in a vertical clump. The spines at the sides of the arms are usually from four to six in number, smooth and solid (except in *Ophiocoma nigra*). One or two tentacle scales are present. There are two genital openings in each inter-radius, beginning outside the mouth shield.

Under the disk granulation is a smooth layer of scales, very fine towards the centre and coarser towards the border, where runs a marginal belt of much larger scales connecting the outer ends of the radial shields, which are oblong, with protruding corners. They are continued inward by a broad stripe of large, strongly overlapping scales—a feature nowhere so well developed as in this genus. The genital plate is like a thick blade, with rounded edges and a slightly clubbed head for articulating with the radial shields, and to the side of which is attached a short, thin, blade-like genital scale. As seen from above, the arm bones are of a very simple structure, being short, with thin, flat, plain-edged wings, and destitute of any forward projections from the upper surface. Their outer and inner faces are of a high type, having the articulating peg and other details well marked. The mouth angles are compactly built and of moderate size, and the mouth clefts are completely covered with hard papillae. The mouth papillae are arranged in an even row, and above them, in a close clump, are the tooth papillae, and still above them, the teeth which have a semi-enamelled grinding end. They are supported by a well marked jaw plate which has little pits above and cross frames below, for the insertion of the minute tooth, and tooth papillae muscles. Outside this are the sockets of the mouth tentacles, of which the upper one has a fixed scale, and the lower one has the outermost mouth papilla as its scale. Outside these, again, may be seen the wing of the mouth frames, the opposite face of which bears the muscle furrows.

The single species of this genus, represented in the Museum collection, *Ophiocoma scolopendrina*, is one of the best known and most widely distributed species of the genus.

Ophiocoma scolopendrina (Lamark).

FIGURE 98.

Ophiura scolopendrina, Lamarck, Hist. Anim. sans vert., Vol. II, 1816, p. 544.

Ophiocoma scolopendrina, Agassiz, Mem. Soc. Sc. Nat. Neuchatel, Vol. I, 1835, p. 192.

Ophiocoma scolopendrina, Müller and Troschel, Wieg. Archiv., Vol. IV, 1840, p. 328.

Ophiocoma scolopendrina, Müller and Troschel, System der Asteriden, 1842, p. 101.

Ophiocoma scolopendrina, Lutken, Additamenta and historiam Ophiuridarum, part 2, 1859, p. 163.

Ophiocoma molaris, Lyman, "Descriptions of new Ophiuridae", Proc. Boston Soc. Nat. Hist., VII, 1861, p. 79.

Ophiocoma scolopendrina, Lyman, "Ophiuridae and Astrophytidae", Illustrated Catalogue, Mus. Comp. Zool., Vol. I, 1865, p. 87.

Ophiocoma scolopendrina, Ludwig, Anatomic der Ophiureu, Zeits. für Wissen, Zoologie, Vol. XXXI, p. 241.

Ophiocoma alternans, (young?), Von Martens, Oph. Ind. Oc. Weig. Archiv., Vol. XXXVI, 1870, p. 251.

Ophiocoma alternans, Lyman, "Ophiuridae and Astrophytidae old and new", Bull. Mus. Comp. Zool. Vol. III, No. 10, Cambridge, 1874, p. 225.

- Ophiocoma scolopendrina*, Duncan, "On the Ophiuridae of the Mergui Archipelago", Journ. Linn. Soc. London, XXI, 1887, p. 93.
- Ophiocoma scolopendrina*, Lyman, "Challenger" Reports, Ophiuroidea, 1882, pp. 169-170; pl. XLVII, fig. 3.
- Ophiocoma scolopendrina*, Bell, "Report on the Zoological Collections of the Voyage of 'H.M.S. Alert', 1884, p. 140.
- Ophiocoma scolopendrina*, Bell J., "Report on the Echinoderms other than Holothurians", in Willey, Zoological Results from New Britain, New Guinea, etc., Part II, 1899, p. 139.
- Ophiocoma scolopendrina*, Andrews, "On the Marine Fauna of Christmas Island", Proc. Zool. Soc. London, 1900, p. 117.
- Ophiocoma scolopendrina*, Koehler, R., Siboga-Expeditie, "Ophiures Littorales", 1905, pp. 60-61.
- Ophiocoma scolopendrina*, Koehler, R., Ophiures et Stellerides recueilles par M. Gravier dans le Mer Rouge (Folfe de Trajurah), Bulletin du Museum, Paris, p. 184.
- Ophiocoma scolopendrina*, Koehler, R., Revision des Ophiures du Museum d' Histoire Naturelle, Bulletin Scientifique, Vol. 44, 1907, p. 326.
- Ophiocoma scolopendrina*, Koehler, R., Ophiuroidea, in Fauna Sudwest Australiens, Vol. I, Lief 4, Jena, 1907, p. 246.
- Ophiocoma scolopendrina*, Clark, H.L., "Some Japanese and East Indian Echinoderms", Bull. Mus. Comp. Zool., Vol. 51, No. 11, 1908, p. 297.
- Ophiocoma scolopendrina*, Mac Intosh, Donald C., "The Marine Fauna of the Mergui Archipelago: The Ophiuroidea", Edinburgh, Proc. Roy. Phys. Soc., Vol. 18, 1911, p. 160.
- Ophiocoma scolopendrina*, Lyman, H.L., "Catalogue of Recent Ophiurans", Mem. Mus. Comp. Zool., Vol. 25, No. 4, Cambridge, 1915, p. 293.
- Ophiocoma scolopendrina*, Matsumoto, "A Monograph of Japanese Ophiuroidea, arranged according to a new classification", Journal of the College of Science, Vol. 38, art. 2, Tokyo, 1917, p. 347.
- Ophiocoma scolopendrina*, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 325, pl. 73, fig. 5; pl. 74, figs. 1-7.
- Ophiocoma scolopendrina*, Gravely, "Littoral Fauna of Krusadai Island, in the Gulf of Manaar", Bull. Madras Govt. Museum (Natural History), I, No. 1, 1927, p. 170.
- Ophiocoma scolopendrina*, Clark, A.M., Echinoderms from the Marshall Islands", Proc. United States National Museum, 102, 1952, 4. 294.

Dr. Gravely (*loc. cit.*, 1927) records a single specimen of this species from Shingle Island in the Gulf of Manaar and has described it as being large and stout, with very thick, smooth spines on the sides of the arms. The colour of this specimen (in alcohol) is reported to be a dull purplish brown.

The ratio of the diameter of the disk to the diameter of the arms is as 1:6. The mouth shields are split directly opposite the mouth and are slightly longer than broad. The teeth papillae are arranged in three rows. The oral shields of the arms are four-cornered with blunt angles and enlarged aboral and lateral margins. The adoral margin is extended into a pointed tip which is covered with the shields which follow next; they are as broad as long. The back shields of the arms are convex at the aboral margin; the adoral margin forms a more or less clear and stumpy or blunt angle; they are twice as broad as long. The spines are in four rows, the upper ones being longer than the lower ones, but thicker, more stumpy and slightly flattened. Two scales are present at the tentacle pore.

The colour in life is reported to be green, but it is lighter in colour below. Darker bands are present on the back of the arms. The spines are light-coloured and ringed with darker rings, or spotted.

This species is subject to considerable variation. Several specimens of this species are reported by Duncan (*loc. cit.*, 1887) in the collection from Mergui Archipelago, and as there are some interesting variations reported among them, they may be mentioned here briefly.

In the largest specimen reported by Duncan, which has a disk diameter of 25 millimetres and arms of a length of 130 millimetres, the upper, swollen, large, flat arm-spine is on every other side arm plate, and near the end of the arm, the upper spine is the longest and the largest, but it is neither flat nor swollen. In one of the specimens reported by Duncan, the normal repetition of a large, flat spine occurs on every side arm plate. The granulation of the disk is hemispherical, small and not crowded; the largest nodules are on the ends of the radial shields. The granulation is smaller below. The wide, generative slits come inwards so as to be bounded orally by the side mouth shields, and these do not always meet orally. Two or three mouth papillae merge into a ridge, and the inner mouth papillae are not readily distinguished from the lower tooth papillae. The mouth shields project considerably along the median line into the jaw angles. The first three lower arm plates form a groove. The double tentacle scale is seen near the disk, but not very far out in the arm; there it is single, large and flap-like. At the tip of the arm the lower arm plates are very long.

Sometimes the spines may be shorter. Duncan (*loc. cit.*, 1887) reports that in a smaller specimen from the Mergui Archipelago diameter of the disk: 22 mm. and length of the arm: 120 mm.), the spines are shorter than in the preceding form, the lower arm plates are broadly elliptical in mid-arm, the skin coming well between them. There is no coalescence of the mouth papillae, and there are three of them on either side and one below the tooth papillae.

The large tentacle-scale in contact with the side mouth shield and first arm plate may be regarded as a mouth papilla.

The granulation may be uneven in some specimens, being crowded and small in the centre and large and spaced out at the margin. In a small specimen reported by Duncan (*loc. cit.*, 1887) (disk diameter: 9 mm. and length of arm: 65 mm.), the granulation of the disk is crowded above and large at the margin. Underneath, the minute scaling, which is obscured by pigment in the large forms, is visible and the granulation does not extend *en masse* to the mouth shields and only a few stray nodules occur thus far inwards.

The mouth papillae are either confused with the lower tooth papillae, or are not, or one may be on the jaw angle external to the tooth papillae clump. Including the large tentacle scale, there are four mouth papillae on either side. The side arm plates come under the arm and are in contact near the disk, but not farther, out. The lower arm plates are rather hatchet-shaped beyond the disk, but they become very long towards the tip. The upper arm plates are widest and convex towards the outside. The spines are miniatures of those of the larger forms. Two tentacle scales are present near the disk and one farther out.

The variations in this species have to do especially with the form and number of the arm spines, the shape of the upper arm plates and of the mouth shields, and the number of the tentacle scales.

Koehler (*loc. cit.*, 1922) reporting on the Ophiurans of the Philippine Seas and adjacent waters, mentions a number of variations occurring in specimens of this species collected in that area. The general colouration of some of these specimens is said to be brownish while the spines are ringed with white. Koehler also reports, that most commonly the tentacle scale in single in the specimens examined by him, from the Philippine Seas.

The under arm plates have the distal border slightly broadened and usually notched in the middle in the Philippine specimens, but Koehler (*loc. cit.*, 1922) reports that this character is also variable, the notching being well marked in some specimens while it is less marked in others.

In all the specimens reported by Koehler from the Philippine Seas, the ventral surface is said to be covered with granules over a more or less extended area; the triangular granulose area thus formed is said to extend toward the mouth shields and always leaves free a more or less broad band along the genital slits. This character appears to be absolutely constant for this species.

This species is a well known and widely distributed one occurring widely in the shallow tropical waters of the Indo-Pacific Region and has been recorded from the Indian Ocean, Red Sea, Philippine Islands, Marshall Islands and the Mergui Archipelago. Besides, Lyman, (*loc. cit.*, 1882), in his "Challenger" Reports has recorded this species from Simon's Bay, Cape of Good Hope (10—20 fathoms); Tongatabu Reefs (18 fathoms); Samboangan Banks, Zebu Reefs, and Fiji Islands.

This species is included in the group of this genus having "two tentacle-scales" according to Lyman's arrangement (Lyman, *loc. cit.*, 1882). A specific diagnostic character of this species, according to Lyman (Lyman, *loc. cit.*, 1882) is that the "arm spines in this species are ringed with darker and lighter colours".

Lyman, (*loc. cit.*, 1882), commenting on this species, reports that so many variations in colour, length of the arms and character of the spines are found in this species that Dr. Ludwig was prompted to combine it with *Ophiocoma erinaceus*. The two are, however, distinguished by the large, central disk scales of the latter.

Specimens in the collection: One fairly large, wet-preserved specimen from Shingle Island in the Gulf of Manaar, collected in 1925, is represented in the Museum's Reference Collection.

The specimen has three of its arms intact, while the other two are broken and detached nearly at their base. The specimen is dark purplish brown above and pale greyish white or dirty white below. The spines at the sides of the arms are very thick, smooth, fairly short, stiff and close set. The upper surface of the disk is covered with close-set granules. The mouth aperture on the oral side is small and star-shaped. The mouth is surrounded by very small, whitish, mouth papillae.

Measurements : Diameter of the disk : 24 mm.
Length of the arm : 180 mm.
Width of the arm
(including the spines) : 12 mm.

Family OPHIODERMATIDAE

As in the preceding family (Ophiocomidae), the disk scalation is concealed on both sides by closely set granules in this family (Ophiodermatidae) also. There are numerous oral papillae in a continuous series; tooth papillae are wanting and the teeth occur in a single row. The arms appear smooth, as the arm spines are small and typically closely appressed to the sides of the arms.

Two genera of this family are represented in the Museum Collection, namely, *Ophiarachnella* and *Pectinura*, the former by one species and the latter by two species. The genus *Ophiarachnella* is closely related to the genus *Pectinura* and resembles the latter very much, but may be readily distinguished from it by the buccal shields being naked, while in *Pectinura* the buccal shields are covered with granules.

Genus *Ophiarachnella* Muller and Troschel.

The disk is granulated completely or with the exception of the naked radial shields and sometimes solitary naked scales. The mouth shields are divided along the horizontal line into an adoral larger section and an aboral smaller section. Between these and the mouth papillae, the granulation of the disk is continued. The mouth bears only the mouth papillae, but there are no tooth papillae on the small teeth. It is this character which distinguishes this genus from the genus *Ophiocoma*. The buccal shields are naked. Two genital clefts are present in every interbranchial area (interradius). Papillae or spines are present on the sides of the arms and scales at the tentacle pores.

A single species, *Ophiarachnella infernalis* (more familiarly known to authors as *Pectinura infernalis*) is represented in the Museum Collection.

***Ophiarachnella infernalis* (Muller and Troschel).**

FIGURES 99 and 100.

- Ophiarachna infernalis*, Muller & Troschel, System der Asteriden, 1842, p. 105.
Ophiarachna infernalis, Ljungmann, Ophiuroidea viventa huc usque cognita, Ofv. K. Vet. Akad., Forh., Vol. 23, 1866, p. 305.
Pectinura infernalis, Lutken, Additamenta ad historiam Ophiuridarum, Vol. III, 1869, p. 15.
Pectinura infernalis, Martens, Die Ophiuriden des Indisches Oceans, Arch. fur Nat., Vol. XXXVIII, 1870, p. 245.
Pectinura infernalis, Lyman, Ophiuridae and Astrophytonidae, Bull. Mus. Comp. Zoology, Vol. III, No. 10, Cambridge, 1874, p. 222, pl. vii, fig. 1.
Pectinura infernalis, Lyman, "Challenger" Reports, Ophiuroidea, 1882, p. 17.
Pectinura infernalis, Bell, Echinodermata, in the Report on the Zoological Collections of "Alert", 1881, p. 134, pl. viii, fig. B.
Pectinura infernalis, Brook, Die Ophiurin-fauna des und. Archipels, Zeit., fur Wiss., Zool., Vol. XXXVII, 1888, p. 471.
Pectinura infernalis, Loriol, P. de, Echinodermes de la baie d'Amboine, Rev. Suisse Zool., Vol. I, 1893, p. 397.
Pectinura infernalis, Koehler, R., Siboga-Expeditie, "Ophiures Littorales", XLVb (-livr. XXI), 1905, p. 7, pl. i, figs. 1, 2 and 3.
Pectinnra infernalis, Koehler, R., Revision des Ophirues du Museum d'Histoire Naturelle, Bulletin Scientifique, Vol. 44, 1907, p. 285.
Pectinura infernalis, Clark, H.L., "Some Japanese and East Indian Echinoderms", Bull. Mus. Comp. Zool., Vol. 51, No. 11, 1903, p. 289.

- Pectinura infernalis*, Koehler, R., "Astéries et Ophiures des îles Aru et Kei", Abh. Senckenb. Naturf. Gesells., Vol. 33, 1910, p. 289.
- Pectinura infernalis*, Mac Intosh, Donald C., The Marine Fauna of the Mergui Archipelago, "The Ophiuroidea", Edinburgh Proc. Roy. Phys. Soc., Vol. 18, 1911, p. 157.
- Ophiarachnella infernalis*, Clark, H.L., "Notes on some Australian and Indo-Pacific Echinoderms", Bull. Mus. Comp. Zool., Vol. 52, No. 7, 1909, p. 124.
- Ophiarachnella infernalis*, Clark, H.L., "Catalogue of recent Ophiurans", Mem. Mus. Comp. Zool., Vol. 25, No. 4, Cambridge, 1915, p. 305.
- Ophiarachnella infernalis*, Matsumoto, "A Monograph of Japanese Ophiuroidea arranged according to a new classification" Journal of the College of Science, Vol. 38, art 2, Tokyo, 1917, p. 324.
- Ophiarachnella infernalis*, Koehler, R., "Ophiurans of the Philippine Seas and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922, p. 341.

The disk is covered, under its granulation, with coarse scales or swollen plates. There are no pores between the under arm plates. The radial shields are naked, as also some other disk plates. There are nine arm spines.

The ratio of the disk to the arms is as 1 : 4. The oral shields are three-cornered and heart-shaped. The smaller shield on the aboral margin is in the form of a half circle. The papillae on the margin are soft, eight at each margin. The teeth in the mouth are cut off across, the sharp point being towards the inner side. In the depth of the mouth groove towards either side of the teeth column, is found a spine-like papilla. The disk is covered with scales, but the scales are covered with fine granules with the exception of a few flat scales which are arranged in a definite pattern : i.e., two of them occur as radial shields between which are three more smaller smooth scales arranged in the form of a triangle, the apex of the triangle pointing towards the centre. A similar smooth scale is found at the disk margin between two arms. The rest of the scales are small. The dorsal shields of the arms have convex, aboral, lateral angles, and are very slightly broader than long. The shields on the oral side have a convex aboral margin, a prominent, greatly developed, lateral margin and two adoral margins, which converge into a blunt, truncated angle. On the lateral shields of the arms are found 8 to 9 pointed papillae, which reach half way up to the next shield, and after the tip of the arms, their number decreases. Two scales are present at each tentacle pore, of which the outer one is smaller.

The colour in life is yellowish brown. Narrow dark horizontal stripes are present on the arms, between which are four shields.

Koehler (*loc. cit.*, 1905) commenting on the specimens of this species examined by him in the Siboga Expedition's Collections reports that they perfectly conform to the description of the typical species, originally furnished by Muller and Troschel. However, he adds the following remarks regarding certain details :

The contours of the radial shield, as well as those on the plates of the dorsal surface of the disk, which the granules do not cover, are very distinct. The radial shields are reniform or oval; the three plates interlaced between the shields of each pair are unequal, the median being larger than the other two. The shields are very close together (crowded), towards the periphery of the disk. The marginal inter-radial plate is always very distinct ; the granules of the disk are very fine.

The buccal shields are triangular, a little longer than broad, with the angles rounded. The supplementary plates, contiguous with the shields are small and semi-circular. The adoral plates are triangular and their summit forms a sharp angle.

The first two branchial dorsal plates are situated in the hollow cleft of the arms. The subsequent plates are not very large, and their external angles are slightly rounded.

The lateral plates, very well developed, carry at the base of the arms, eight and sometimes nine spiny branchiae, which do not reach the middle of the plate.

A drawing of this species furnished by Lyman represents the dorsal face of the disk, without granules. Bell (*loc. cit.*, 1884) has also published a diagram of the dorsal surface of this species. According to this author, the three plates in triangle which separate the two radial shields of each pair are not always quite distinct. Koehler, however, doubts whether this species figured and described by Bell may not be *Pectinura similis*, rather than *Pectinura infernalis*.

This species is widely distributed in the Indo-Pacific Region and has been recorded from the Japanese Seas, Philippine Seas and adjacent waters, the Mergui Archipelago, the Indian Ocean and the East Coast of India.

Specimens in the collection.—One wet-preserved specimen, in a fairly good condition, is represented in the Museum's Reference Collection. Locality : Rameswaram Island, Gulf of Manaar.

The specimen is pale on the ventral side, almost whitish, with the arms distinctly cross-banded with brown. The mouth aperture is star-shaped. The spines on the sides of the arms are minute. The aboral side is brownish, the cross bands on the arms being darker brown. The disk is more or less pentagonal, flattened and granulated on the aboral side. The interbranchial spaces are fairly wide.

Measurements : Diameter of disk : 10 mm.

Length of the arm : 32 mm.

Interbranchial space on the aboral surface : 5 mm.

Genus *Pectinura* Forbes.

The disk is granulated. Teeth and numerous even, close-set mouth papillae are present, but there are no tooth papillae. The spines are smooth, shorter than the arm joints, numerous (5 - 15). The tentacles are rarely one, usually two in number, in which case the upper one overlaps the base of the lowest arm spine. An indentation is present in the back of the disk at the base of each arm. A supplementary plate is present just outside the true mouth shield. Two genital openings are present in each interbranchial space.

The disk is enclosed by a coat of stout, imbricated scales and strong radial shields. The genital plates, thick and rather wide, are attached to short, stout, genital scales. The mouth frames and jaws are strong and finely curved and bear three thick peristomal pieces of which two form an angle, whose opening outward is wedged by the third. The arm bones are of a high type, having thin wings, and the umbo, articulating peg and other subordinate parts are well marked.

The genus *Pectinura* is distinguished from the closely related genus *Ophiopeza* only by having a supplementary plate outside the mouth shield, and both are distinguished from *Ophiura* by the minor anatomical character in this last genus (*Ophiura*) that, by a partial adhesion of the edges of the genital openings, each one is divided into two. The skeleton is more or less similar in these three genera.

Two species, *Pectinura conspicua* and *Pectinura intermedia*, are represented in the Museum Collection. The former is a deep sea form, attaining a very large size, and is distinguished from the latter by the disk being very strongly hollowed or deeply cleft or incised at the bases of the arms. The former species is referred by some authors to the genus *Bathypectinura*, but since the differences between *Bathypectinura* and the typical *Pectinura* are not very well marked and significant, except for the fact that *Bathypectinura* includes the deep sea species of *Pectinura*, it has been decided to retain the better known and more familiar generic name *Pectinura* instead of *Bathypectinura* for assigning the species *conspicua* in the present account.

***Pectinura conspicua* Koehler.**

FIGURE 101.

- Pectinura conspicua*, Koehler R., Annales des Sciences Naturelles, Zoologie, 8th Series, Vol. VI, 1897, p. 322, pl. vi, figs. 36 and 37.
- Pectinura conspicua*, Koehler, R., "An Account of the Deep Sea Ophiuroidea collected by the R. I. M. S. Ship "Investigator", Calcutta, 1899, p. 37, pl. ii, fig. 14 and 15.
- Pectinura conspiciua*, Koehler, R., Ophiures de l'Expedition, du Siboga, pt. 1, Ophiures de mer profonde, Leiden, 1904, p. 9, pl. i, fig. 1.
- Pectinura modesta*, Koehler, R., *Ibid.*, 1904, p. 7, pl. ii, figs. 4-6.
- Pectinura elata*, Koehler, R., Resultats Scientifiques de la Campagne du Caudan dan le golfe de Gascogne, Echinodermes, Lyon, 1906, p. 7, pl. i, figs. 1-3.
- Pectinnra elata*, Koehler, R., Revision des Ophiures du Museum d'Histoire Naturelle, Bulletin Scientifique, Vol. 44, 1907, p. 249, pl. 18, figs. 1 - 3.
- Pectinura elata*, Koehler, R., Ophiures Resultats Scientifiques des Campagnes du Travailleur et du Talisman, Vol. 8, 1907, p. 284.
- Bathypectinura conspicua*, Clark, H.L., Notes on some Australian and Indo-Pacific Echinoderms, Bull. Mus. Comp. Zool., Vol. 52, No. 7, 1907 p. 130.
- Bathypectinura modesta*, Clark, H.L., *Ibid.*, 1909, p. 130.
- Bathypectinura elata*, Clark, H.L., *Ibid.*, 1909, p. 130.
- Bathypectinura conspicua*, Clark, H.L., Catalogue of Recent Ophiurans, Mem. Mus. comp. Zool., Vol. 25, No. 4, Cambridge, 1915, p. 306.
- Bathypectinura modesta*, Clark, H.L., *Ibid.*, 1915, p. 307.
- Bathypectinura elata*, Clark, H.L., *Ibid.*, 1915, p. 306.
- Pectinura heros*, Clark, H. L., *Ibid.*, 1909, p. 130.
- Bathypectinura heors*, Clark, H. L., *Ibid.*, 1915, p. 307; 1909, p. 130.
- Pectinura tessellata*, Lyman, "Report on the Ophiuroidea", Results of the Dredgings of the Blake, Bull. Mus. Comp. Zool., Vol. 10, 1883, p. 230, pl. 3, figs. 1-3.
- Bathypectinura gotoi*, Clark, H.L., *Ibid.* 1909, p. 130.
- Bathypectinura tessellata*, Clark, H. L., *Ibid.*, 1915, p. 306; 1909, p. 130.

Bathypsectinura gotoi, Matsumoto, "A new classification of the Ophiuroidea", Proc. Acad. Nat. Sciences Philadelphia, 1915, p. 37.

Bathypsectinura gotoi, Clark, H.L., *Ibid.*, 1915, p. 326.

Bathypsectinura conspicua, Koehler, R., "Ophiurans of the Philippines and Adjacent Waters", Bull. United States National Museum, 100, Vol. 5, 1922 p. 342.

This species is regarded as one of the largest species known, among the Ophiuroids. In the majority of the specimens, the diameter of the disk exceeds 35 mm. and in some it attains a diameter of even 40 mm. The length of the arm ranges from 18 to 20 centimetres. Their width at the base is about 6 mm.

The disk is flattened, pentagonal, and even slightly excavated in the interbrachial spaces. It is very strongly hollowed (i.e., deeply cut or incised) at the base of the arms. The dorsal face is uniformly covered with fine and serrated granules. When these granules are detached, the plates underneath may be seen. These plates are small, narrow and imbricated. The peripheral plates are a little larger than the others, and particularly one plate at the middle of the interbrachial space towards the border of the disk is much longer than its neighbours and this plate always remains naked. Outside it, there are a few other small, naked plates. The radial shields, which are also naked, are regularly oval; their length is less than a third of the radius of the disk; they are largely separated. Between each pair of radial shields, the disk bears a radial depression which is continued up to the centre.

The ventral surface is covered in the interbrachial spaces with granules identical to those of the dorsal surface, but less serrated and the plates underneath could be distinguished easily.

The buccal shields are sufficiently large, triangular, broader than long, with a proximal angle bounded by two slightly concave sides and a rounded distal border. The lateral angles are evenly rounded. The supernumerary plate which is found outside is small and semi-circular. These shields are completely naked. The adoral plates are very much elongated, strongly narrowed in their interval region which is covered with granules, widened at their external extremity which is naked. The oral plates are low (flat) and small, evenly covered with granulation. The buccal papillae are six or seven in number on each side. The exteriormost one is very large and broad; the two succeeding ones are also long and wide, with their free margin rounded; the others are conical and pointed. The odd terminal papilla is large and conical.

The first dorsal brachial plates, numbering four generally, which are contained in the hollow cleft of the arms are smaller than the others, which are large, quadrangular, very much broader than long; the lateral borders are slightly divergent and the two wide margins are straight. These plates cover the entire dorsal surface of the arms which do not reach the lateral plates. They are very strong and very high, carinated (or keeled), and of such a form that the section of the arm has the shape of a triangle.

The first brachial ventral plate is small, trapezoidal with a proximal border rounded and broad, a narrow distal border and concave lateral borders. The other plates, wider than long, have a proximal narrow side, two lateral divergent sides excavated by the tentacular pores and a distal border very broad and concave.

The lateral plates are small, developed solely on the ventral side; they carry three spines (and often four on the first ten plates), larger than half of the plate, narrow and pointed.

The tentacular pores are furnished with a large, rounded scale; there frequently occurs two tentacular scales on the first pair and sometimes even on the second pair. Besides, there are generally five pairs of fine pores between the ventral brachial plates. This does not appear to be absolutely constant and certain.

This species is a very variable form and the considerable variations in this species accounts for the various synonymous names for this species, such as *Pectinura elata*, *P. modesta*, *P. heros* and *P. tessellata*.

The type specimens of this species examined by Koehler in the Investigator Collection are from the delta of the Godavary in India at a depth of 110 fathoms. The principal characters of the species are the very large size, the diameter of the disk reaching 40 mm., the shape of the mouth shields which are a little broader than long, the number of the arm spines which are at least four, decreasing to three at a little distance from the arm base, the occurrence of numerous pores between the under arm plates at the base of the arms, and the presence of a large tentacle scale.

This species has a very vast geographical range of distribution, for it occurs in all the three great Oceans—the Atlantic, the Indian and the Pacific. Its bathymetric range is also rather great, since the extreme limits of the depths at which it has been collected are 393 metres (215 fathoms) and 335 metres (183 fathoms) on the one hand and 2,503 metres (1,375 fathoms) on the other.

Specimens in the collection.—Four spirit-preserved specimens from the Bay of Bengal, are represented in the Museum's Reference Collection. In addition to these, there is one wet-preserved specimen from the Bay of Bengal, mounted and exhibited in the Gallery.

The specimens are fairly large, pale creamy white in colour (in alcohol). The disk is large and in the form of a flattened, pentagonal body, with the interbrachial spaces wide and somewhat inwardly indented. The arms are long, slender, narrowed and pointed towards the tip. The arms are somewhat laterally compressed, and more or less triangular in cross-section, their upper margin forming a more or less sharply angular edge. The radial shields are conspicuous, but the spines at the sides of the lower surface of the arms are very small and reduced, and in a view from above, the spines appear to be practically absent. The aboral side of the disk is almost smooth, with radial depressions extending from the centre towards the bases of the arms. On the oral side, the mouth appears as a star-shaped aperture in the centre and there are deep, slit-like depressions on either side of the bases of the arms extending inwards from the edge of the disk to the centre of the disk.

The specimens are in a very fragile condition in the spirit reference collection, and the slender arms break off at the slightest touch.

Measurements: Diameter of the disk: 32 mm.

Interbrachial space (i.e., distance between bases of two adjacent arms: 16 mm.

Length of the arm: 130 mm.

Thickness of the arm: 5 mm.

Pectinura intermedia Bell.

FIGURE 102.

Pectinura intermedia, Bell, F.J., "Report on a Collection of Echinoderms made at Tuticorin by Edgar Thurston", Proc. Zool. Soc. London, 1888, p. 386.

This species can be included in the same group of genera of *Pectinura* which includes *P. gorgonia*, *P. marmorata* and *P. stellata* of Lyman's arrangement; for it has the disk covered under its granulation with coarse scales and there are pores between the first and second arm plates; but the disk is flat, with the arm compressed from time to time and keeled superiorly, while there eight arm spines.

The radial shields are naked, of moderate size, rather irregularly elliptical in form; the rest of the disk is covered superiorly by a coarse granulation, beneath which are plates of fair size. The arms are widest at their insertion to the disk, and are distinctly carinated; accessory mouth shields are of fair size; pores are present between the first and second arm plates only; near the base of the arms there are eight spines; the upper arm plates are not broken. Eighteen mouth papillae are present, the outermost on either side being small; its neighbour is the largest of the series. There are four teeth. The mouth shields are irregularly hexagonal, the adoral edge being the shortest. The accessory mouth shields are irregularly semi-circular in form. The side mouth shields tend to be of the form of an equilateral triangle. The granulated space between the mouth papillae and the mouth shield is well marked.

The lower arm plates at first are wider than long; further out they become unequally hexagonal, owing to the encroachment of the side plates on the adoral edge. The upper arm plates, near the edge of the disk, are quite three times as wide as they are long; further out their adoral edge becomes encroached on, and overlapped by, the side plates; the carination is best marked on the proximal half of the arm. While there are eight arm spines near the base, there are only six some distance away from the base; the spines are always delicate and short; the two lowest are a little longer than the rest; but they are never as long as the side arm-plate. Two tentacle scales are present.

The disk, above, is of a brownish colour, with yellowish patches and black dots; the radial shields are lighter, as is also the oral surface. The arms are banded lighter and darker, in sets of four or five; in the case of the darker bands the most proximal and the most distal plates are a good deal darker than the intermediate three.

In an average adult specimen of this species, the diameter of the disk is about 16 to 18 mm., the length of the arm about 75 mm. from the edge of the disk, the width of the arm at the disk about 4 to 3.5 mm., and the height of the arm about 3.5 mm.

This species has been recorded by Bell from Tuticorin and was reported in a collection of Echinoderms made by Edgar Thurston, former Superintendent of the Madras Government Museum, from Tuticorin on the East Coast of South India.

Specimens in the collection.—One dry-preserved specimen of this species, collected at Pamban in the Gulf of Manaar, is exhibited in the Gallery collection of Echinoderms in this Museum.

The specimen is uniformly dull brownish. The disk is pentagonal, with the arms arising at the angles of the pentagonal disk. The arms are slender, long, tapering and pointed at the extremity. The upper surface of the disk is granular and bears two large oval plates near the margin at the base of each arm. The radial overlapping shields on the arms are conspicuous and the lateral shields on either side of the central plates are also prominent. The spines at the sides of the arms are small, short and inconspicuous and are seen only towards the basal part of the arms in the present specimen. The upper surface of the disk is quite flattened.

Measurements: Diameter of the disk: 18 mm.

Length of the arm: 60 mm.

Width of the arm at the base: 5 mm.

ORDER EURYALAE

This Order includes the forms commonly known as the Basket stars. The arms are often slightly or greatly branched and are long and flexible and are even capable of coiling around objects or rolling up in a vertical plane; the arms can twist and turn to grip objects. The body is generally covered with naked or granulated skin and mostly lacks definite scales or shields except for the radial shields that are long and radiate from the central part of the disk to its periphery and may be smooth or spiny. The disk may

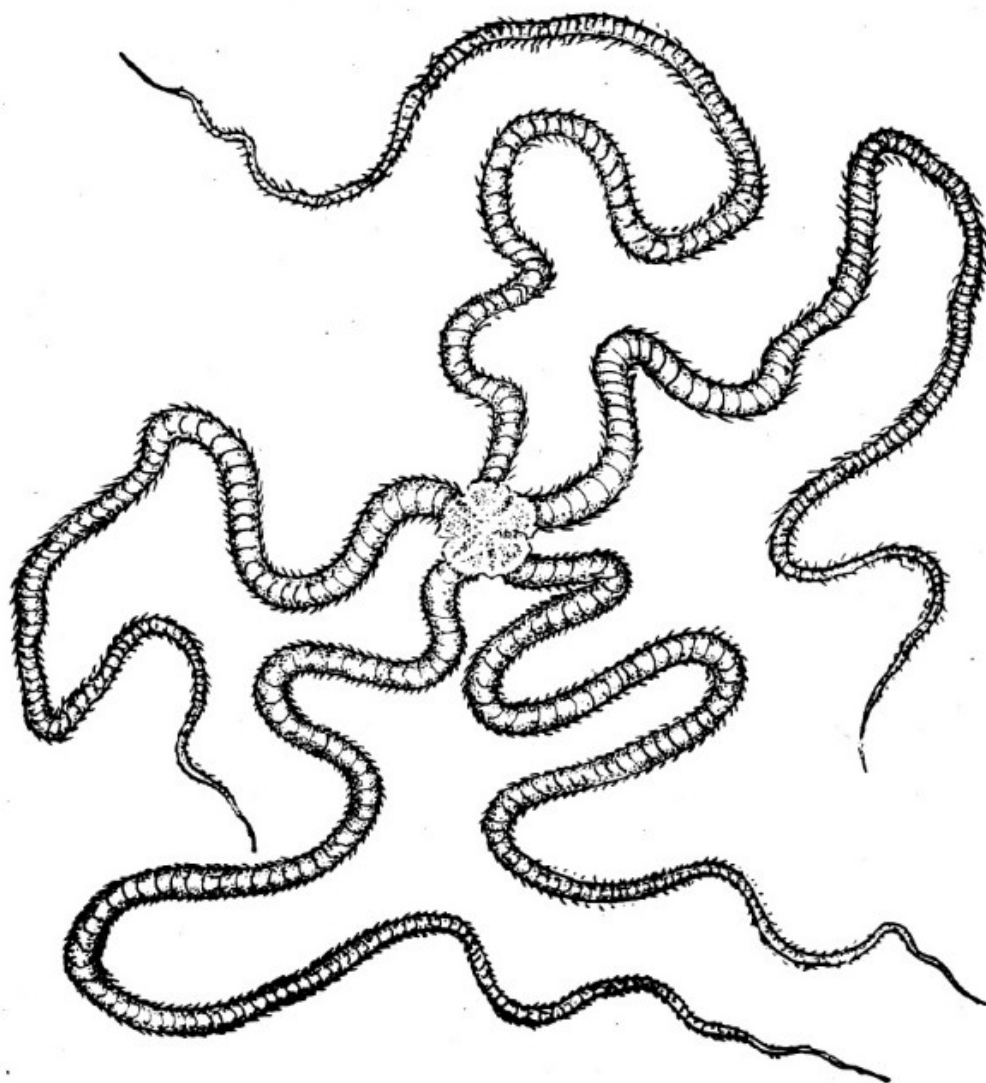


Fig. 86. *Amphioplus gravelyi* (James).
(Dorsal view) ($\times 4$).

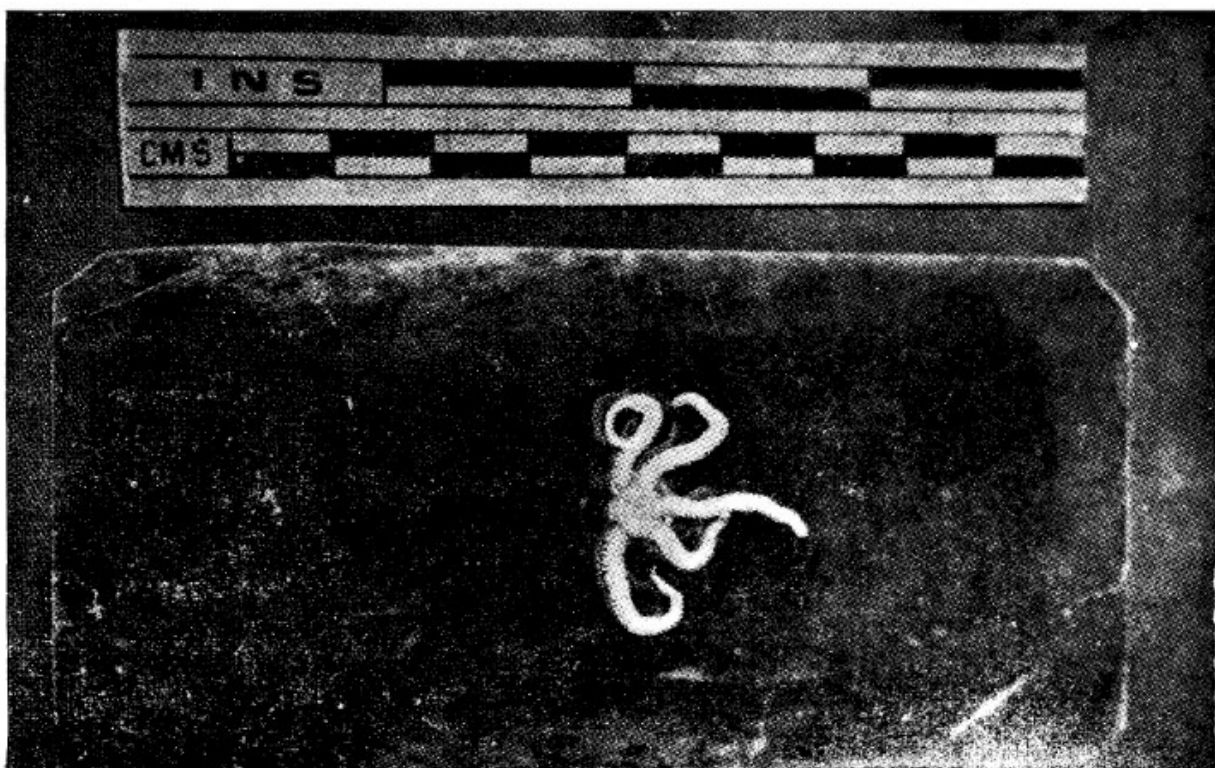


Fig. 87. *Ophiactis savignyi* (Muller and Troschel).
(Dorsal view).

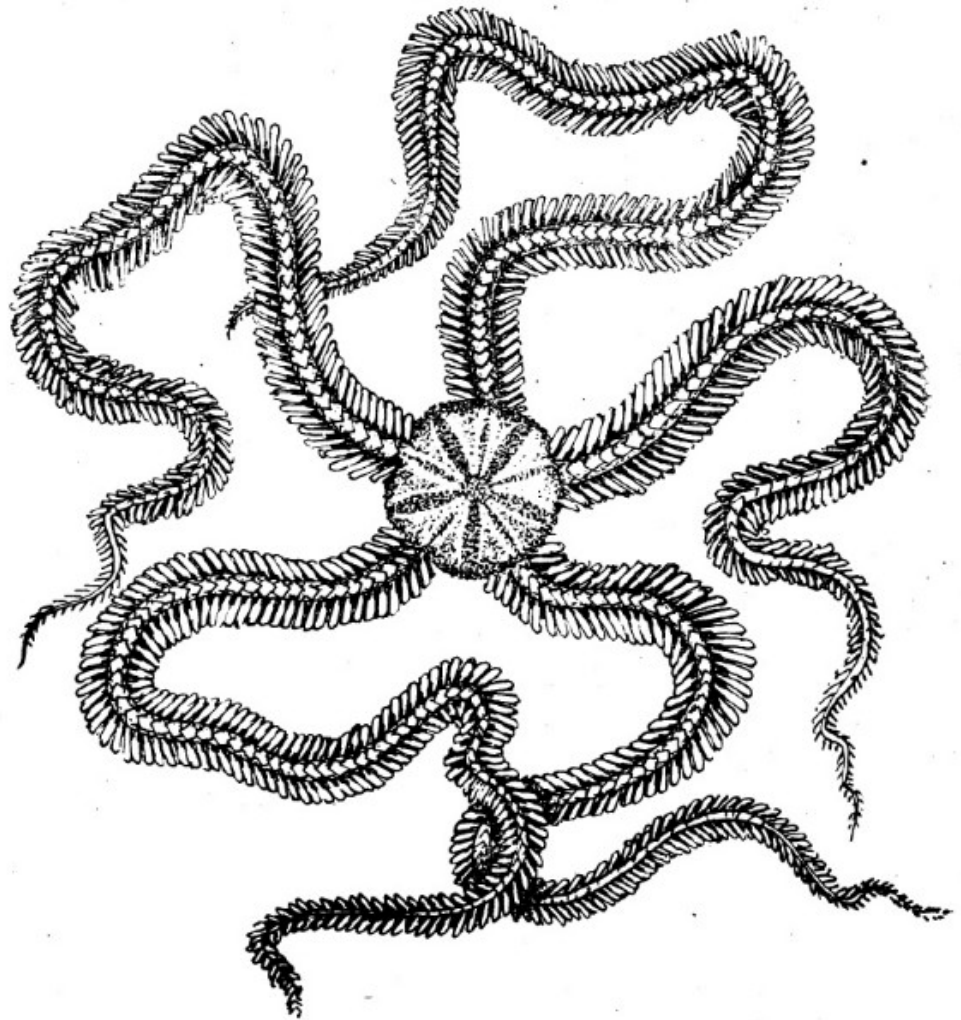


Fig. 88. *Ophiothrix hirsuta* (Muller and Troschel).
(Dorsal view) ($\times 1\frac{1}{2}$).

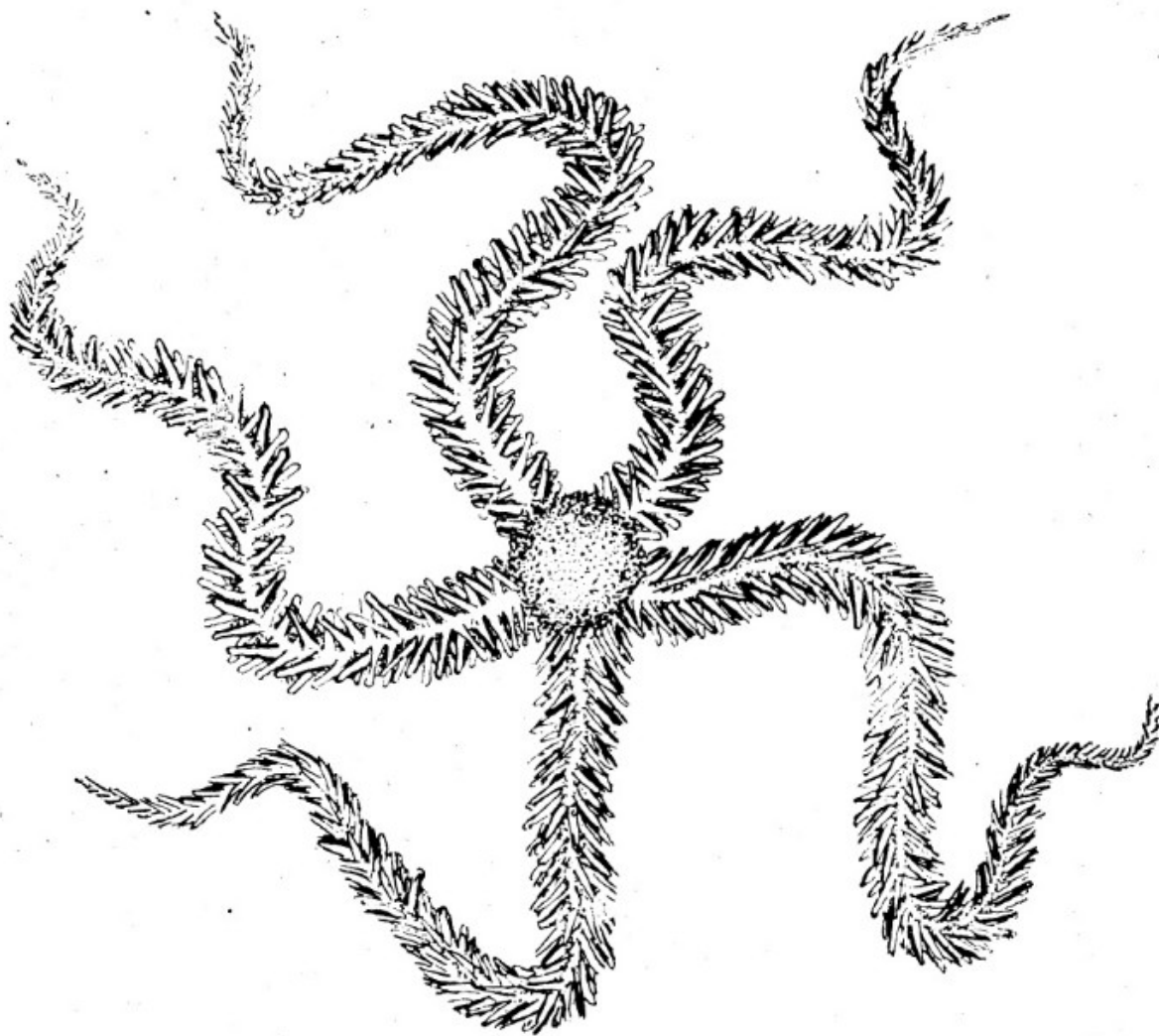


Fig. 89. *Ophiothrix koreana* (Duncan).
(Dorsal view) ($\times 3$).

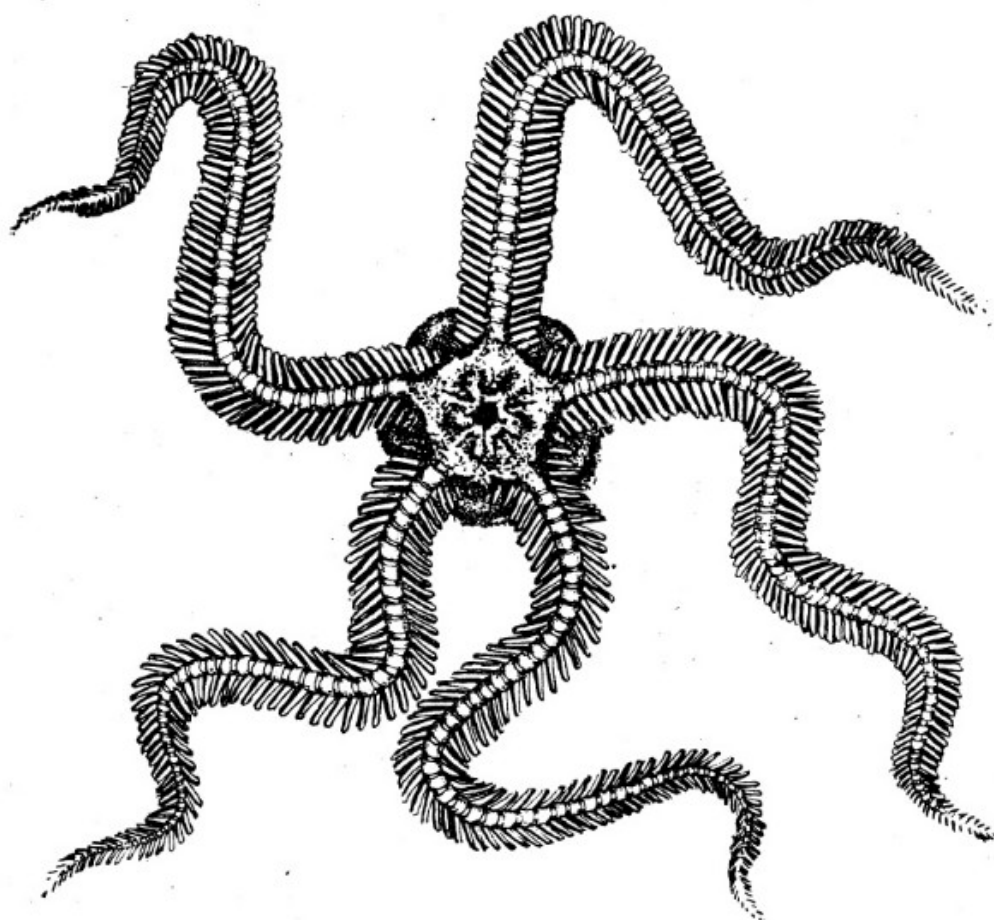


Fig. 90. *Ophiothrix koreana* (Duncan).
(Ventral view) ($\times 3$).

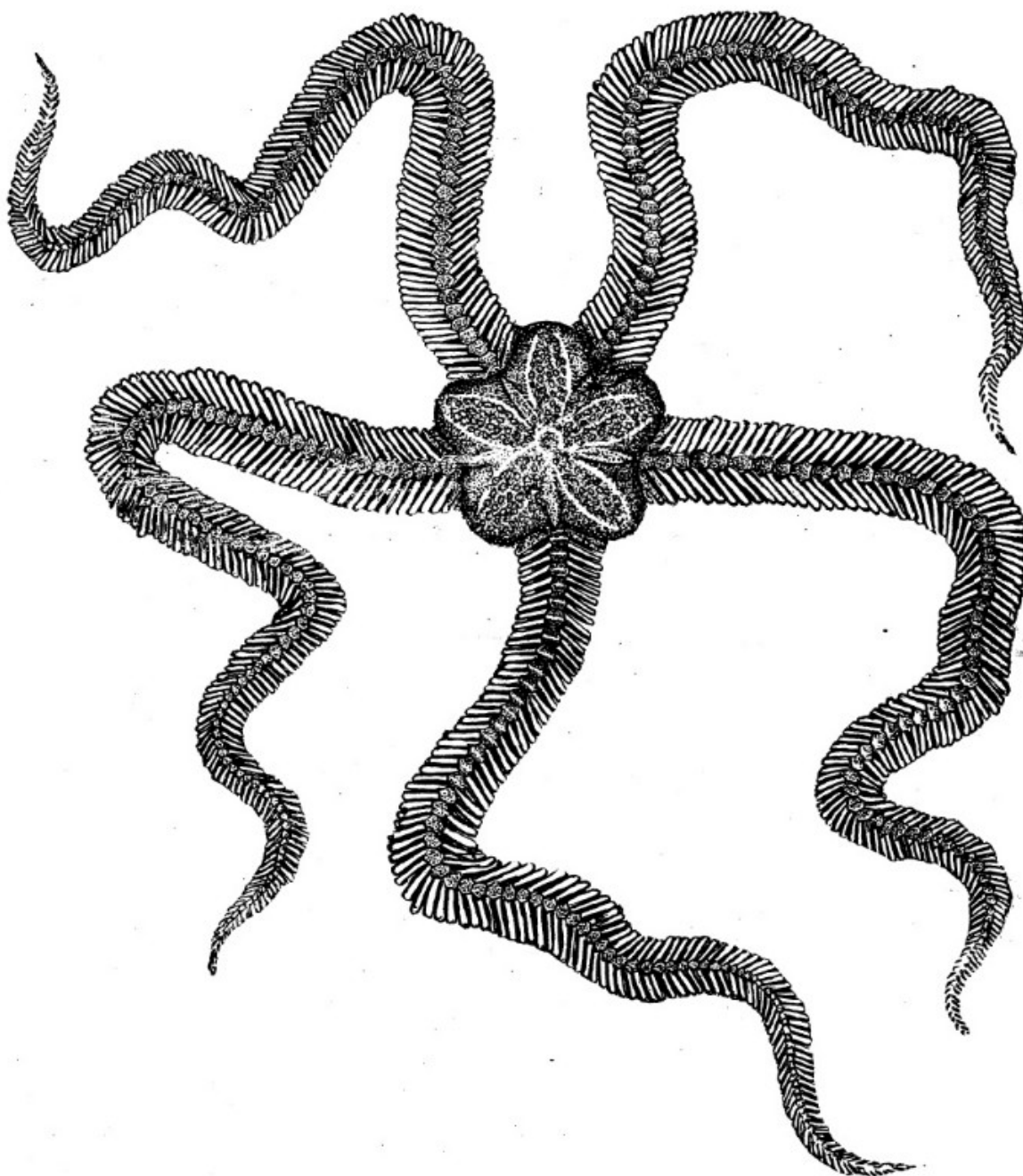


Fig. 91. *Ophiothrix aspidota* Muller and Troschel.
(Dorsal view) ($\times 1\frac{1}{2}$).

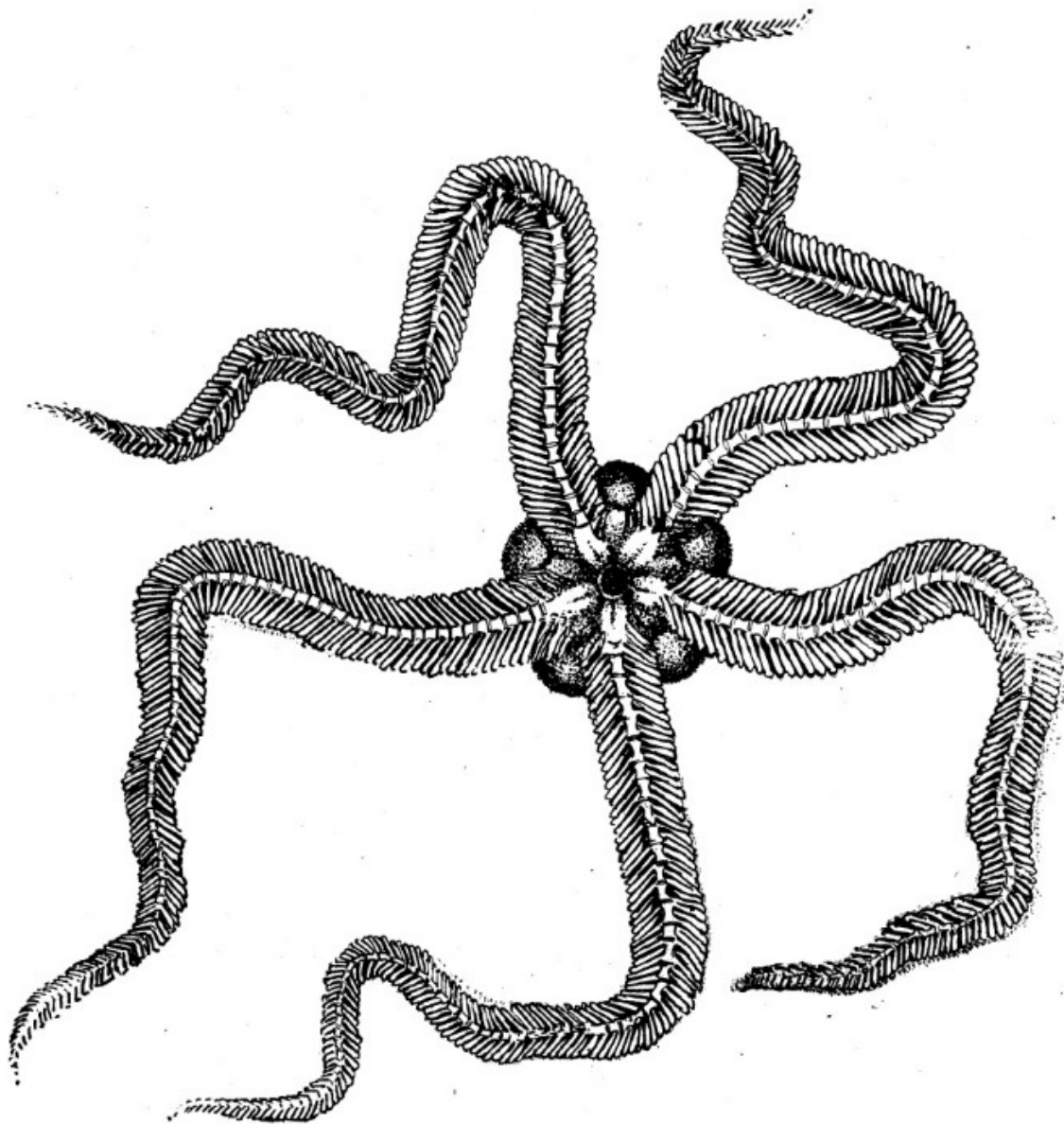


Fig. 92. *Ophiothrix aspidota* Muller and Troschel.
(Ventral view) ($\times 1\frac{1}{2}$).

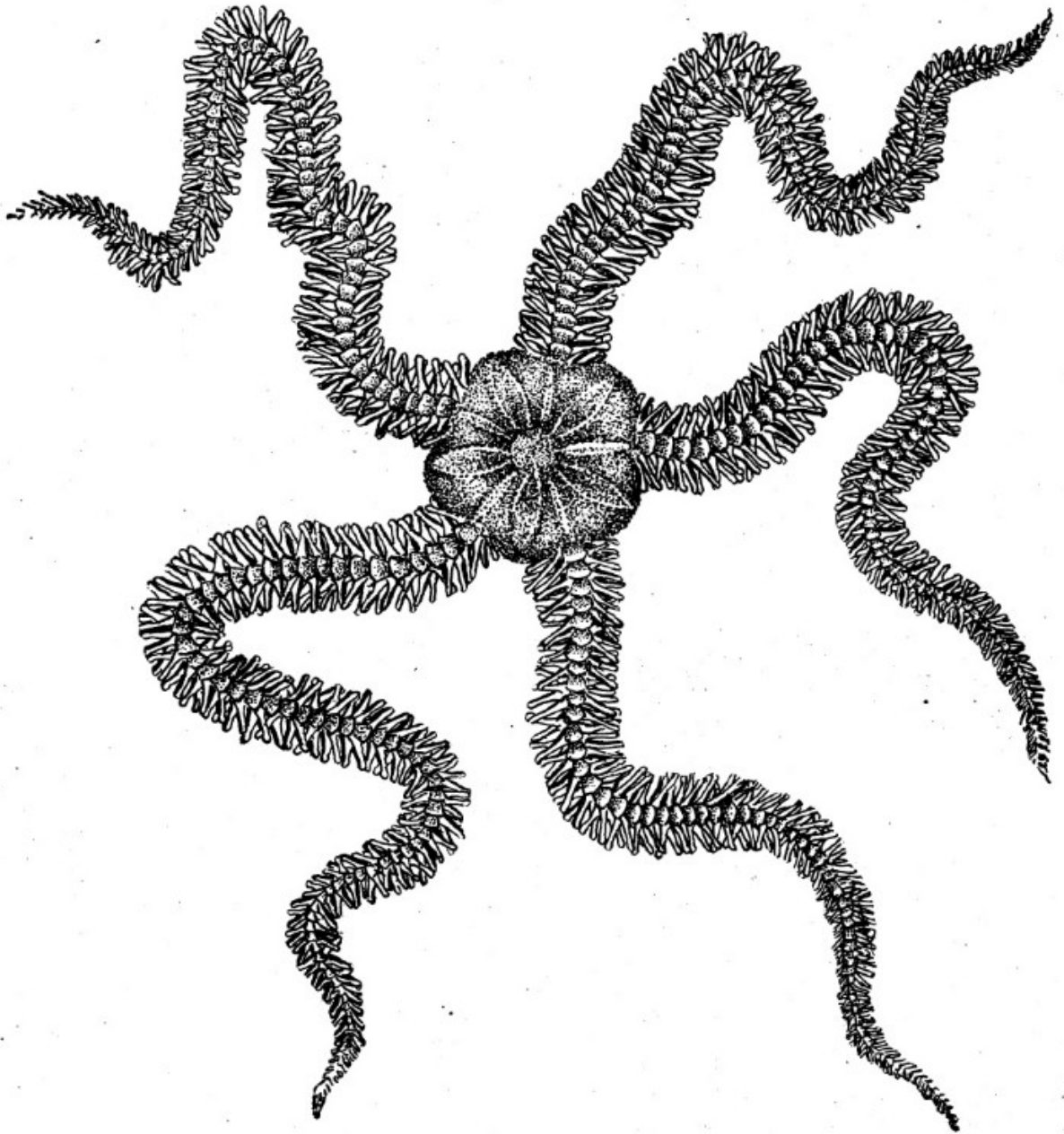


Fig. 93. *Ophiothrix galathea* (Lutken).
(Dorsal view) ($\times 1\frac{1}{2}$).

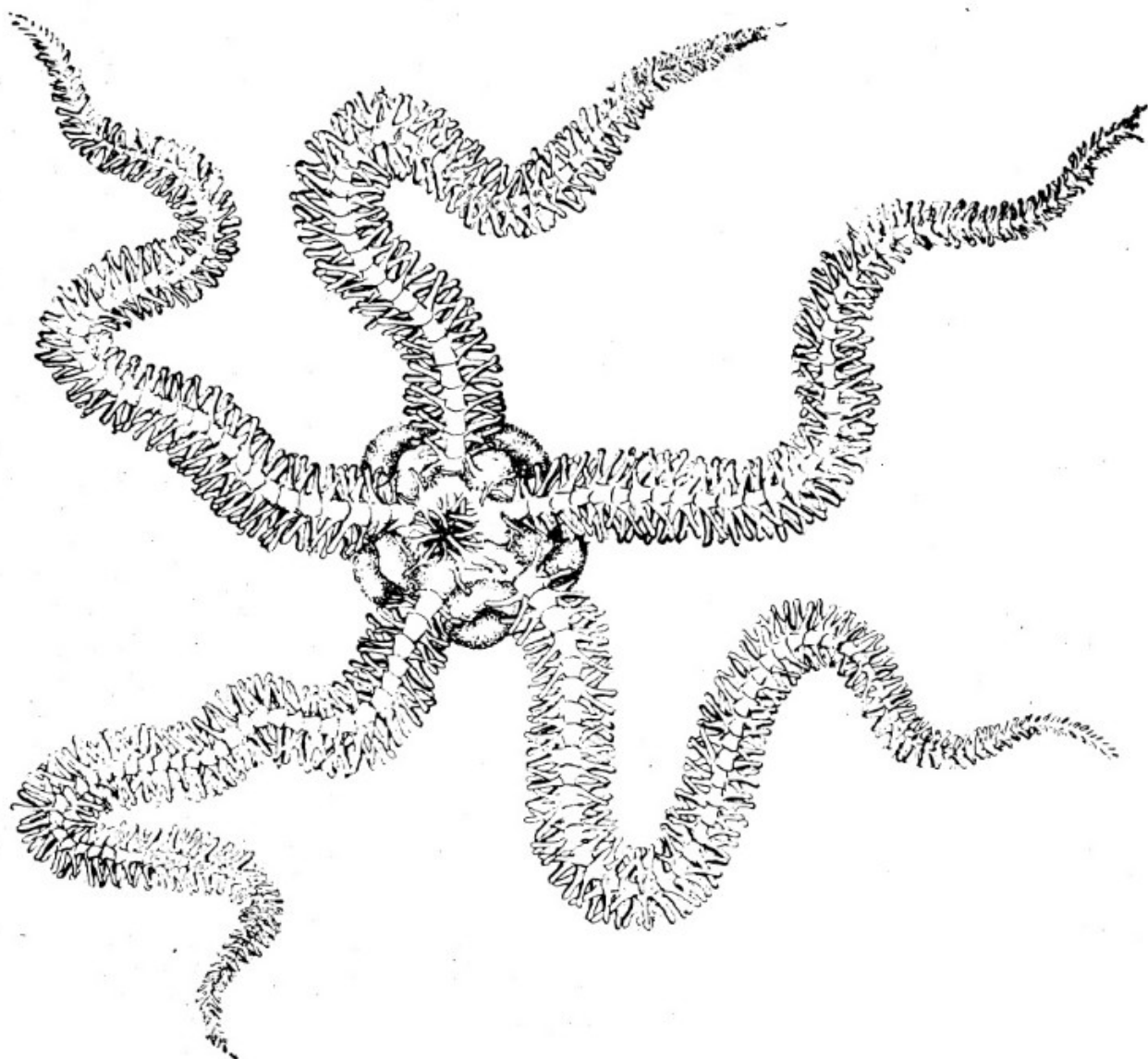


Fig. 94. *Ophiothrix galathea* (Lutken). (Ventral view) ($\times 1\frac{1}{2}$).

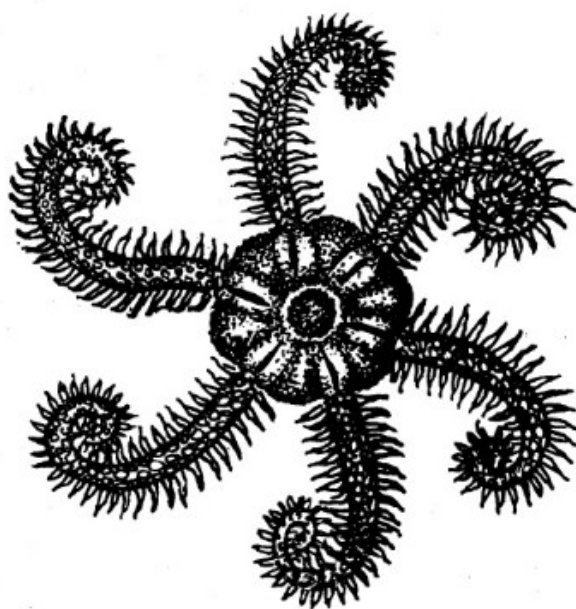


Fig. 95. *Ophiothela danae* (Verrill). (Dorsal view) ($\times 4$).

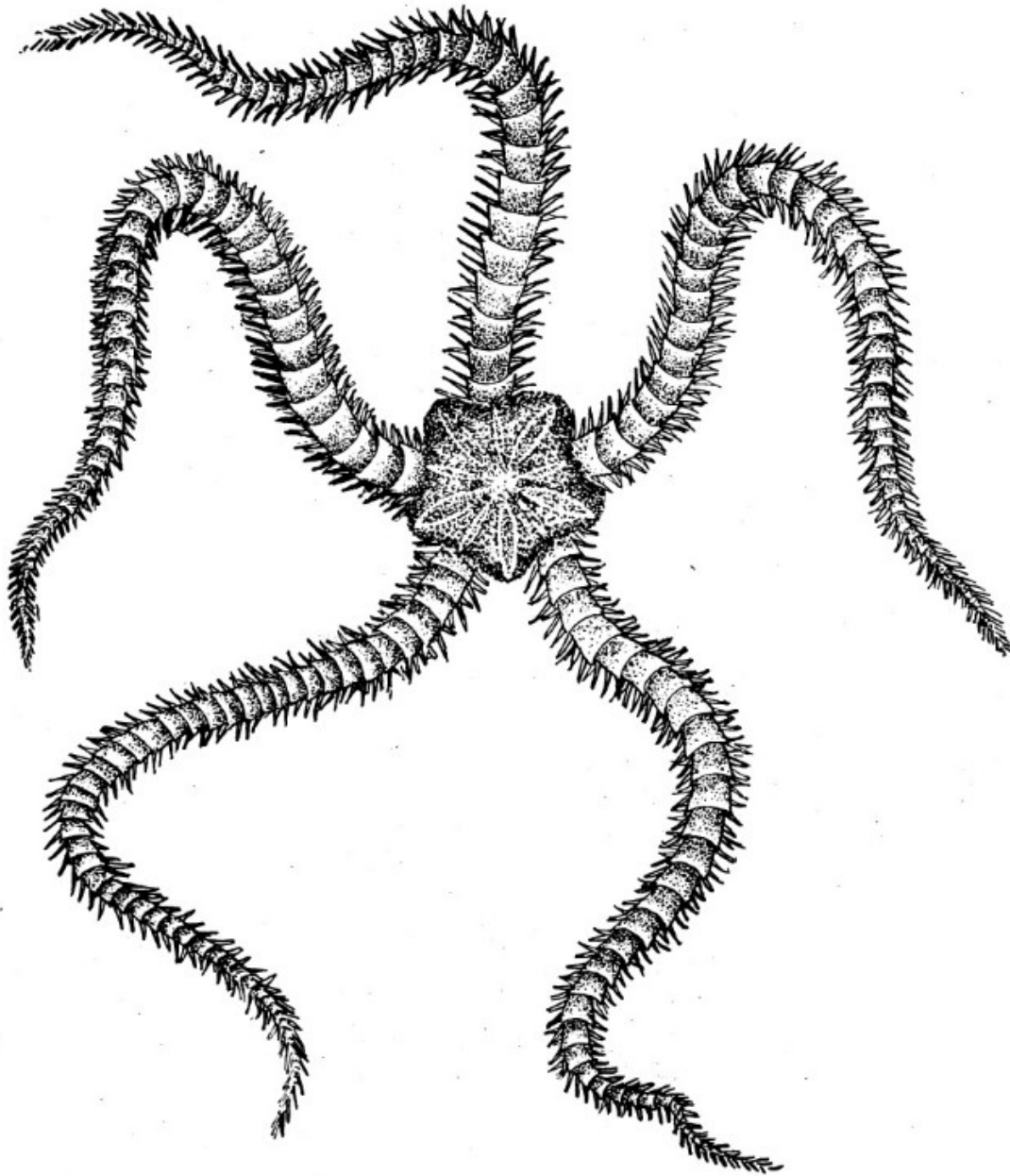


Fig. 96. *Ophiocnemis marmorata* (Muller and Troschel).
(Dorsal view) ($\times 1\frac{1}{2}$).

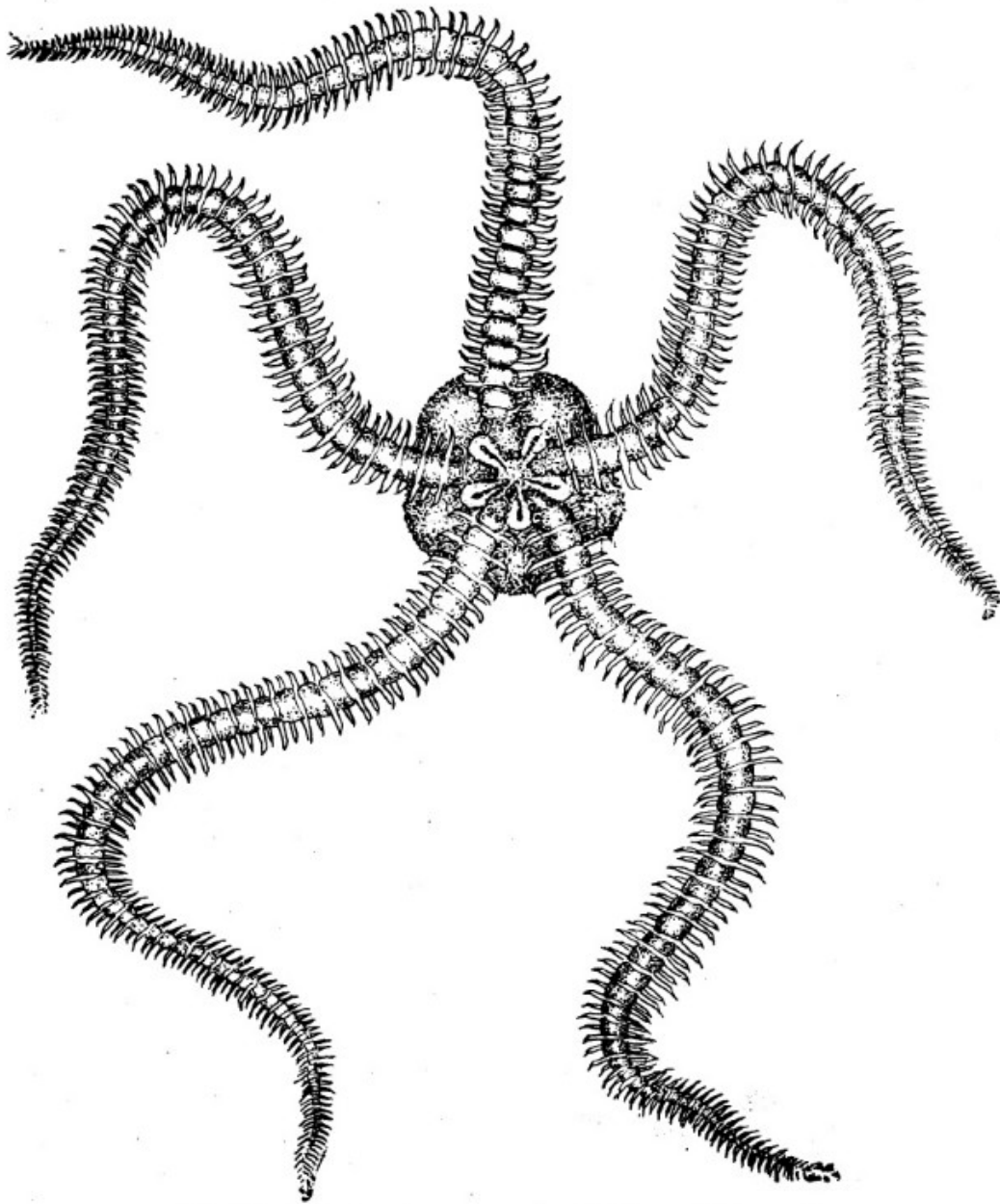


Fig. 97. *Ophiocnemis marmorata* (Muller and Troschel).
(Ventral view) ($\times 1\frac{1}{2}$).

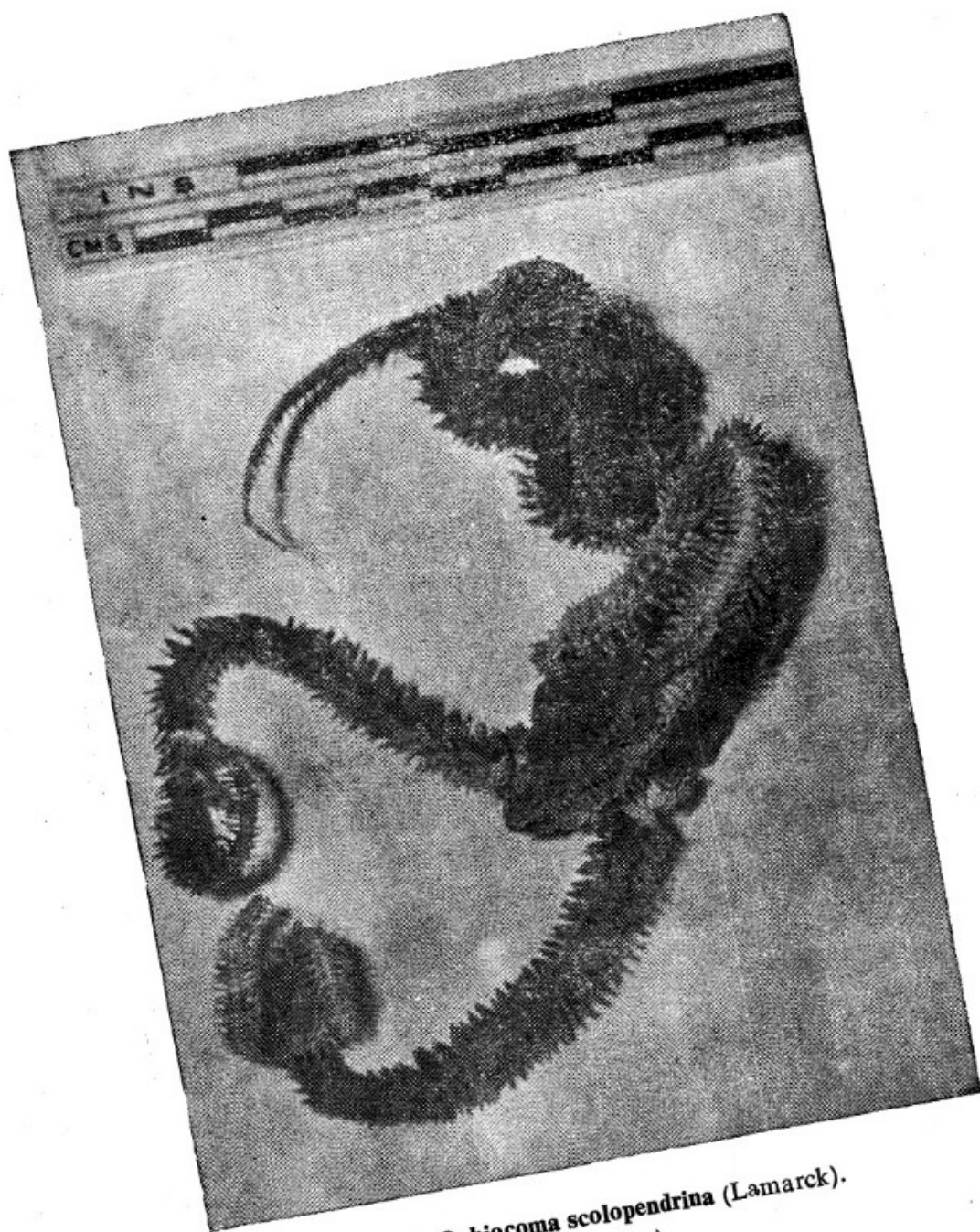


Fig. 98. *Ophiocoma scolopendrina* (Lamarck).
(Dorsal view).

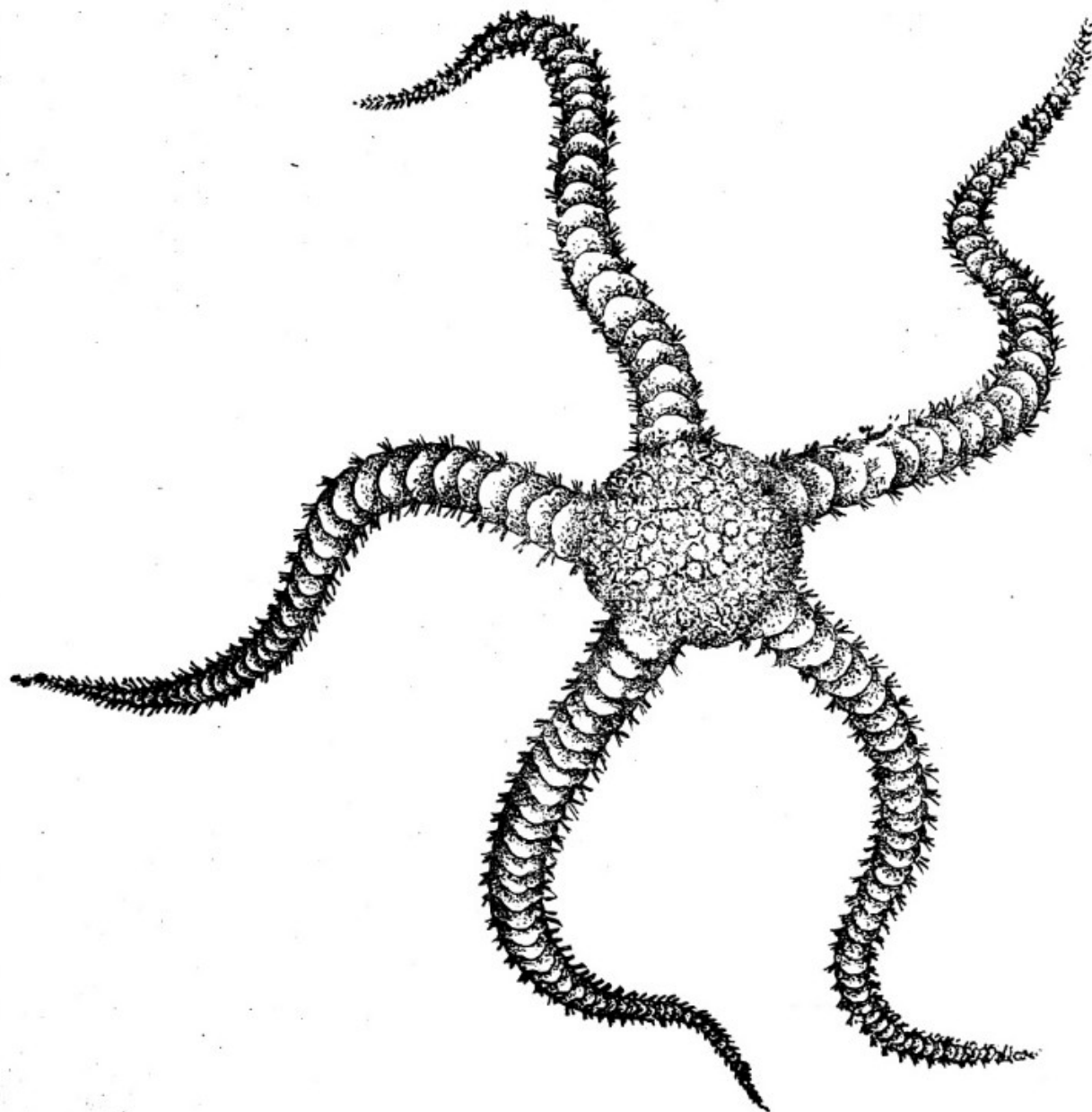


Fig. 99. *Ophiarachnella infernalis* (Muller and Troschel).
(Dorsal view) ($\times 2$).

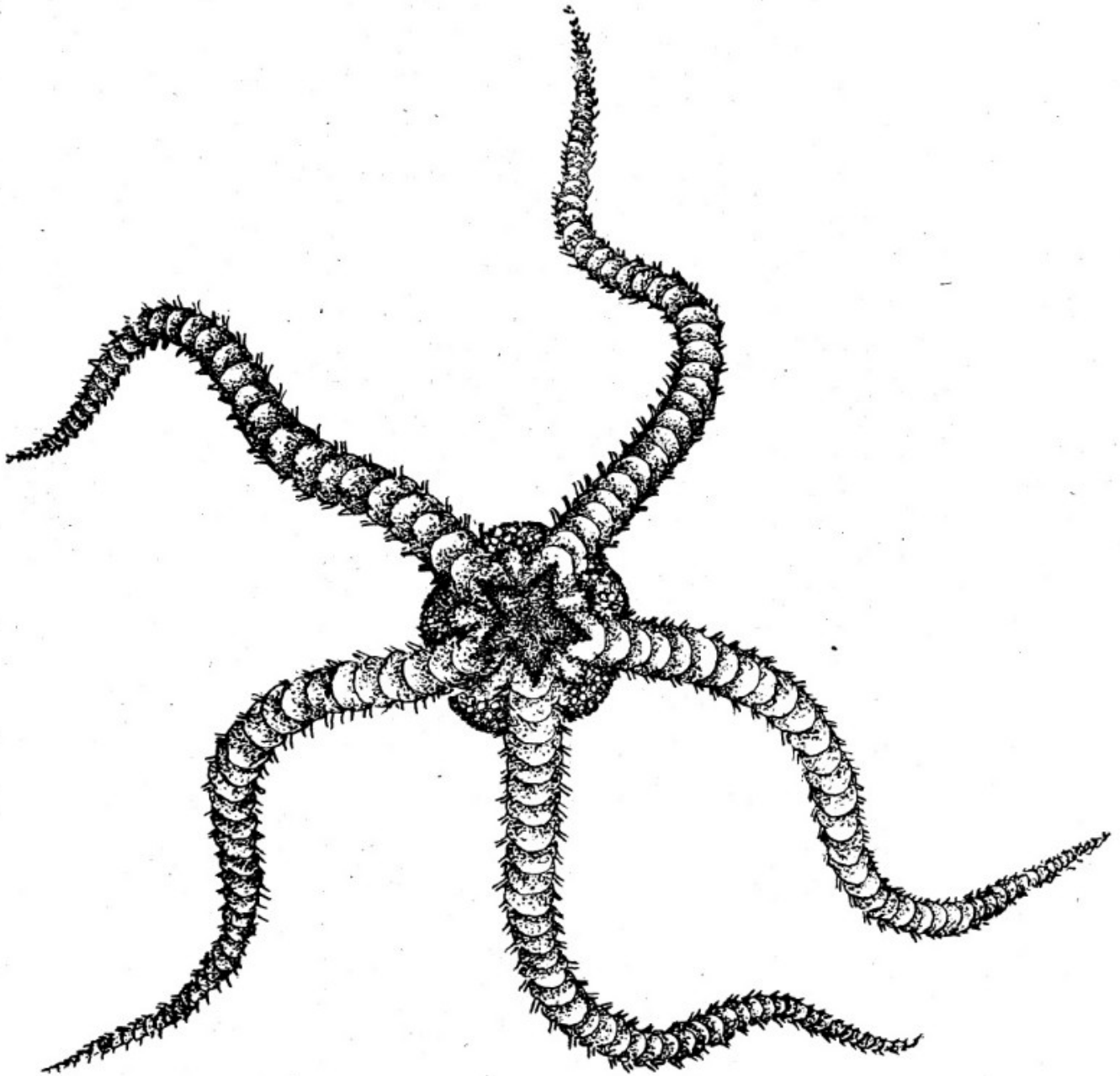


Fig. 100. *Ophiarachnella infernaliis* (Muller and Troschel).
(Ventral view) ($\times 2$).

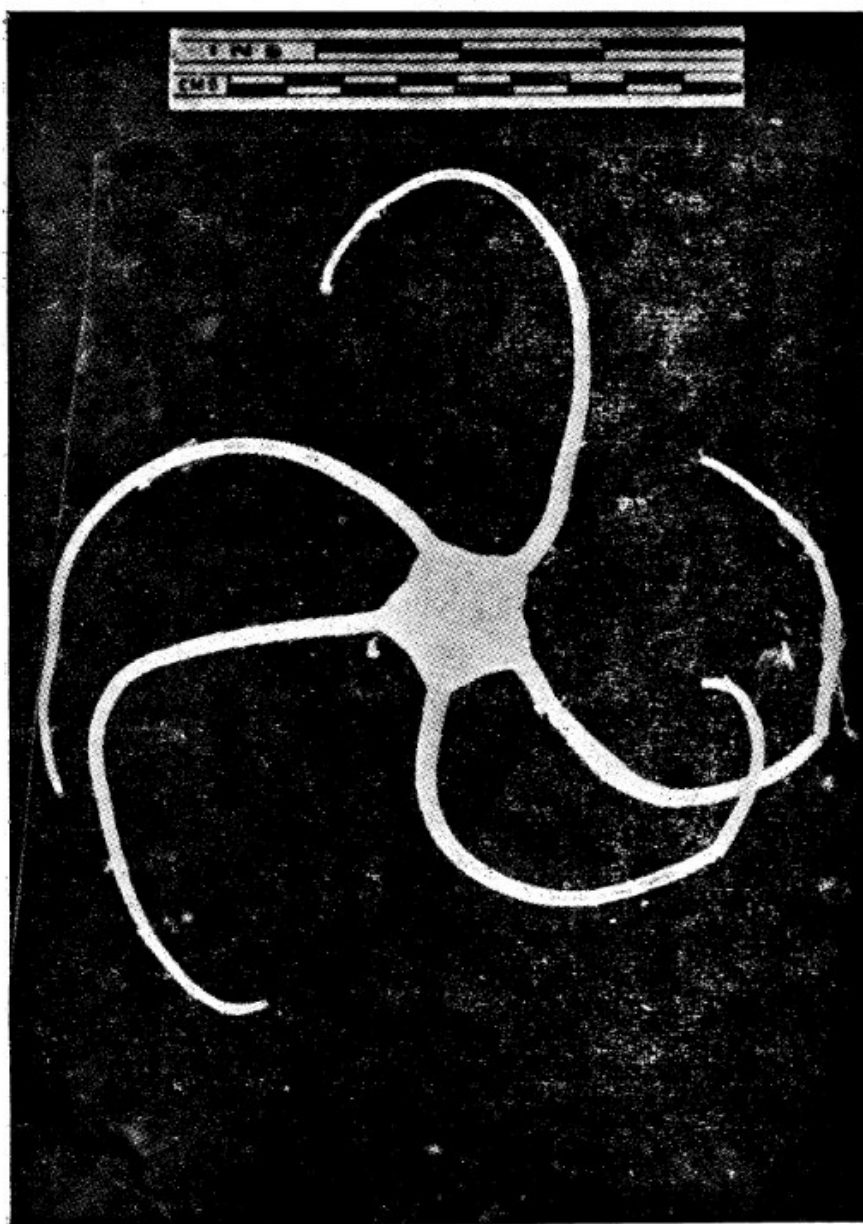
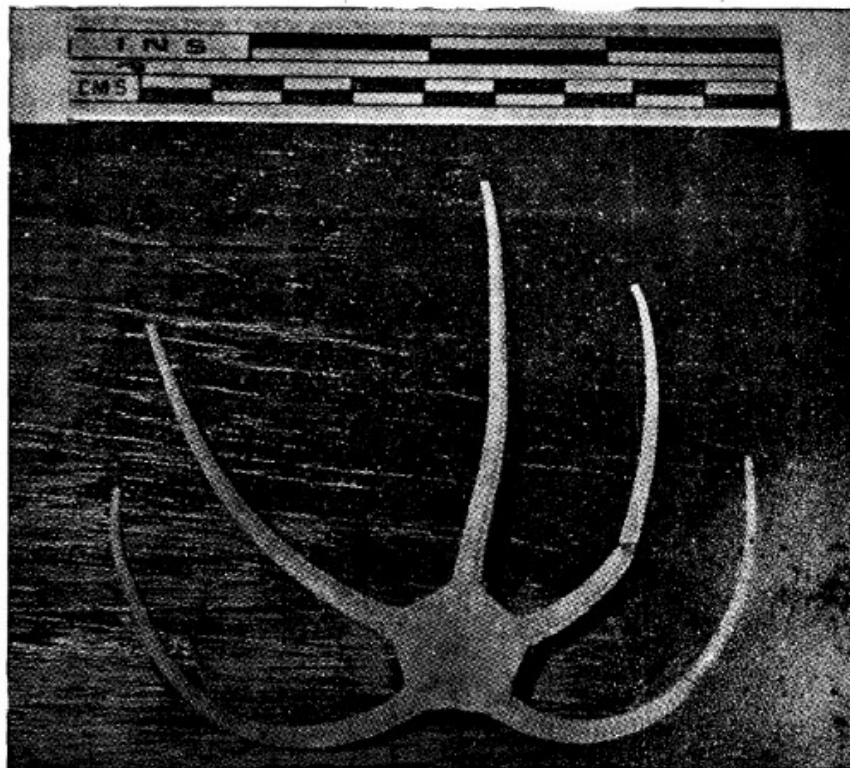


Fig. 101. *Pectinura conspicua* (Koehler).
(Dorsal view).



Fig, 102. *Pectinura intermedia* (Bell).
(Dorsal view).

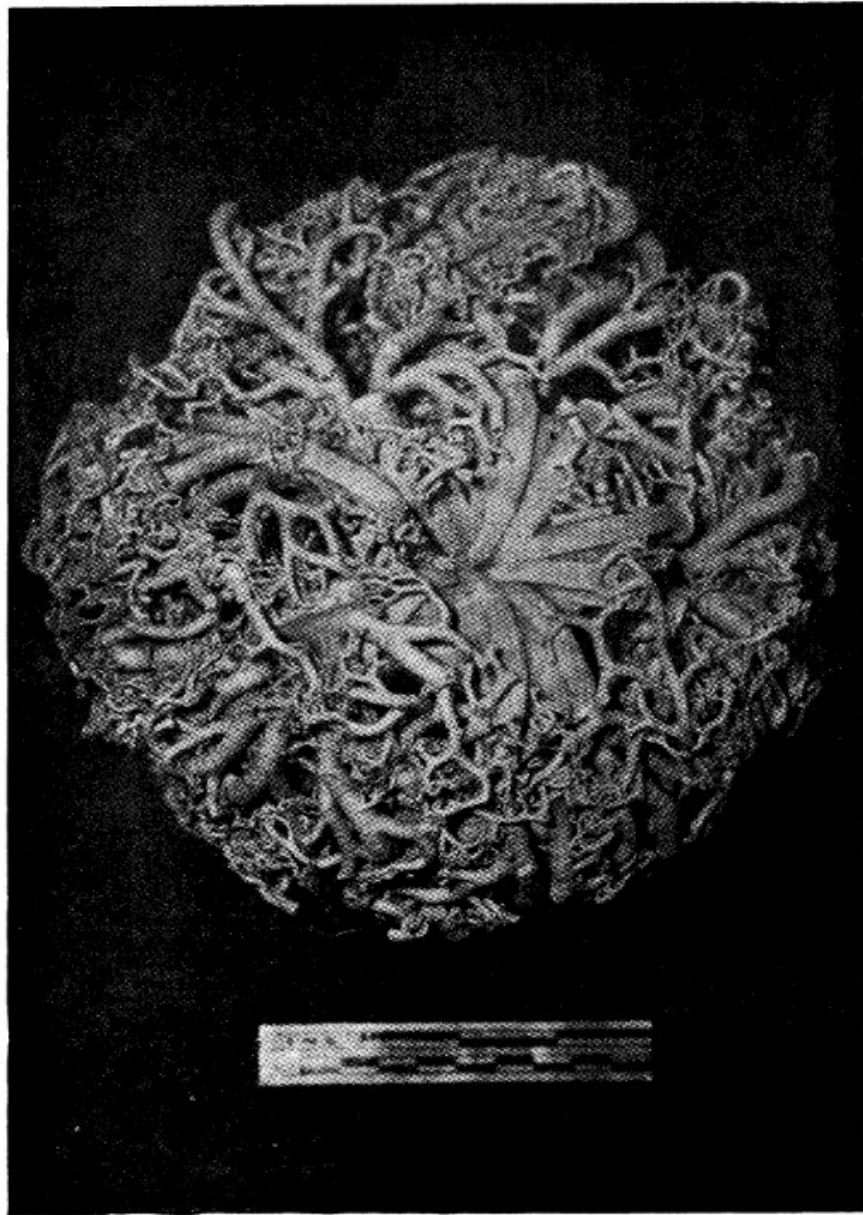


Fig. 103. *Gorgonocephalus laevigatus* (Koehler).
(The Basket Star: General View).

be very large, often reaching a diameter of 10 centimetres especially in the family Gorgonocephalidae. The short arm spines, displaced towards the ventral surface of the arms and directed downward, are often transformed into hooks or spiny clubs. The bursal slits are generally short and the bursae tend to fuse internally to form large spaces. A madreporite may be present in each interradius in keeping with the increased number of stone canals and related structures. The members of this order are mostly inhabitants of deep waters and are hence known chiefly from collections dredged from the seas.

A single species belonging to the genus *Gorgonocephalus* (*Gorgonocephalus laevigatus*), included in the family Gorgonocephalidae, is represented in the Museum Collection.

Family GORGONOCEPHALIDAE.

This family includes the largest and most typical members of the Order of Basket stars. The disk is large and covered with a naked or granulated or tuberculated skin that does not conceal the long, bar-like radial shields often ornamented with spines or tubercles. Oral papillae, tooth papillae and teeth form a continuous series of small, spine-like projections. The arms are very long, simple or slightly or greatly branched and much coiled vertically. There are no true aboral arm shields, but these are often represented either along the whole arms or on their distal parts by transverse bands of hook-bearing granules and hence the arms have an annulated appearance when viewed from the aboral side. Lateral and oral arm shields are present. There may be a single madreporite or one in each interradius.

Genus *Gorgonocephalus* Leach.

This is one of the best known genera of the family Gorgonocephalidae, and includes some of the typical species of basket stars. The disk is thick and inclined to be circular, and together with the arms, is covered by a thick skin. The arms are narrow at their base and branching by a series of not numerous forks, having between them long, unequal shafts. The radial shields are long and bar-like, composed of overlapping, soldered plates, and extending nearly or quite to the centre of the disk, thus forming more or less elevated, radiating ribs. The margin of the disk and inner angle of the interbrachial spaces are strengthened by irregular horizontal rows of plates. Teeth, tooth papillae and mouth papillae are all similar and spiniform. No true arm spines are present, but the outer branches have spiniform tentacle scales which, with the tentacles, are found quite to the base of the arm. Both the finer twigs and smaller branches of the arms are ringed with double lines of grains bearing microscopic hooks. The side arm plates are confined to the under surface and lower sides of the arms. On the small branches the under arm plates are divided in three pieces, which increase in number towards the base of the arm, and there form an irregular pavement.

The upper arm plates are represented by numerous thin, irregular plates, forming a mosaic. Two genital openings are present at the outer corners of the interbrachial spaces.

Gorgonocephalus laevigatus Koehler.

FIGURE 103.

Gorgonocephalus laevigatus, Koehler, R., Echinoderms recuilles par "l'Investigateur" dans l'Océan Indien, I, Les Ophiures de mer profonde, Annales des Sciences Naturelles, Zoologie, Huitième série, Vol. IV, 1897, pp. 277-372; pl. v-ix; p. 365; pl. ix, figs. 78 & 79.

Gorgonocephalus laevigatus, Koehler, R., An Account of the Deep Sea Ophiuroidea collected by the R. I. M. S. Ship "Investigator," Indian Museum, Calcutta, 1899, p. 71, pl. xii, fig. 97; pl. xiv, fig. 99.

The disk is deeply excavated in the interradial spaces. The dorsal surface is covered by a thin, transparent integument, soft and perfectly smooth, presenting neither spines nor granules of any sort, and devoid of all calcareous deposits. The radial shields appear neatly through the transparency, under the integument, which remains smooth. One recognizes easily on the surface of these ribs, the rounded strae corresponding to the lines of separation of the successive calcareous deposits. These shields are very long and narrow relatively to their length; they are a little thicker in the proximal half than in the distal part. The peripheral extremity of each shield is widened and flattened and forms a semicircle articulating with the extremity of the corresponding genital plate which forms equally a semicircle.

The ventral surface of the disk, in the interbranchial spaces, is covered, like the dorsal surface, by a thin and smooth integument (skin). The genital slits are very much elongated, their length ranging up to 15 millimetres; they are equally very wide.

The tooth papillae (dental papillae) and the teeth have the same form and not distinguishable from each other: they are elongated, spiniform, and disposed very close to each other in several vertical series. The mouth papillae are also spiniform, but smaller than the preceding, separated from each other, forming a small, irregular group of three or four papillae on each side.

The arms are very wide at the base. The ventral surface is concave, especially on the primary ramifications; the dorsal face is very convex and a longitudinal furrow or groove extends throughout its length. It remains even visible on the ramifications (branchings) of the sixth order. The successive branches (or segments) are separated by wide intervals, with undulated contours. On each segment, a double row of fairly regular, rounded granulations may be distinguished, which are contiguous and slightly protuberant and prominent. These granulations together form a band which is also as wide as the space which separates two neighbouring bands.

The ventral face of the arms is entirely smooth. The three or four primary pairs of pores are devoid of papillae; the two or three succeeding pairs possess a single one, then the succeeding ones have two. On the branches which follow the second bifurcation there are invariably three such papillae. These papillae are elongated, cylindrical, with blunt extremity. The points which bound the central calcareous network generally appear to become visible only after treatment with caustic potash.

The species *Gorgonocephalus laevigatus* is characterized especially by the interradial spaces being strongly excavated (or hollowed out), by the development of the genital slits, and by the complete absence of all ornamentation on the dorsal face of the disk. By this last character it approaches a variety of the species *Gorgonocephalus eucnemis* described by Danielssen and Koren under the name of *G. Malmgreni* and of which the disk is almost smooth, but it differs in all the other characters indicated above.

Koehler (*loc. cit.*, 1899) has recorded this species from the following localities: Trincomale: Long 81° 17 feet 45 inches, Lat. N. 8° 40 feet 10 inches. Depth 200-350 fathoms. One specimen from this locality, examined by Koehler, is reported to be in a very good condition (Diameter of the disk: 47 mm.). Colombo, Ceylon, at a depth of 142-400 fathoms; one specimen has been reported from this locality, but in a very bad condition. (Diameter of the disk: 33 mm.).

Specimens in the collection.—One large specimen of "basket star" of this species, preserved in formalin, is contained in the Museum's Reference Collection. Locality: From off Nagapattinam, Thanjavur District, collected in 1930.

The specimen is pale creamy white, with the arms very wide at the base. The arms are repeatedly branched and encircled by distinct annular rings (ribs).

The branching of the arms proceeds in a tree-like manner until the final branches at the extremities are extremely fine, slender, curled and tendril-like.

The specimen is fragile and brittle and the distal portions of the branched arms tend to break off at the slightest touch.

Measurements :

Overall diameter of the entire specimen : 200 mm.

Length of the basal part of the arm (from the base up to the primary ramification : 52 mm.

Thickness (or width) of the basal portion of the arms : 9 mm.

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NOTE.—The following list includes some of the more important and better known references to literature on the Echinodermata, including many standard works of reference on this Group. For other references, the reader is referred to the bibliographies appended at the end in many of the publications cited in the following list, as well as to the list of references cited in the body of the present paper at the beginning of the description of each species. A fairly complete and exhaustive Bibliography of the Echinoderms of the Indian Ocean has been prepared recently by Messrs D. B. James and R. S. Lal Mohan and has been brought out in the form of a cyclostyled Bulletin (No. 15) of the Central Marine Fisheries Research Institute, September, 1969. This has been cited as the last entry in the following list, and will be found extremely helpful.

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